

## ABSTRACT

Title of Thesis: FROM THE SOLAR DECATHLON TO  
SUSTAINABLE COMMUNITIES

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Science, 2018

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This thesis explores the potential to use the fundamental elements of UMD's decathlon submission, and transform it into scalable, modular, fully customizable, and sustainable houses for the Native Tribes, including Apache reservation in Bylas, Arizona. The thesis summarizes the various prototypes and possible arrangements of a solar home, but first lays out significant precedent analysis for sustainable solar communities to form a strong baseline of rich context. The history and culture of the resilient nomadic Apache tribe is then analyzed in order to better understand what is and is not appropriate design-wise for this culture. It explores options, a decision-matrix using a smartphone application, and layouts using the courtyard, compact and cluster arrangements. It concludes with sample houses and building designs that would be in the community.

FROM THE SOLAR DECATHLON TO SUSTAINABLE COMMUNITIES

by

Christopher Paul Courtney

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## **Chapter I: Introduction**

The University of Maryland's design team for the Department of Energy's Solar Decathlon competition has been considering from the start, a design that would be able to be adaptable to different climate zones through its ability to flexibly expand and aggregate with other homes. Only one official design is entered into the competition to be built, but the ideas of customizability and growth are evident in the marketability category of the Solar Decathlon. This thesis will look at organizing the many variables of customizability, but also narrow in on some specific untapped options that the design concept could branch towards, especially in the case of a desert community concept within reservation land owned by the Apache Tribe. While not every single option and climate can be tested in this thesis, the overall concept of *how* it could work will be tested in Bylas, Arizona. But before analyzing the site and program of the thesis, a brief description of the Solar Decathlon competition and basic summary of the past design work done is needed.

### **Description of the DOE's Solar Decathlon:**

According to the Solar Decathlon's website, the purpose of the U.S. Department of Energy's design competition is to "challenge collegiate teams to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive."<sup>1</sup> It simultaneously educates the public and students on

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<sup>1</sup> NREL. "About Solar Decathlon." Solardecathlon.gov. Accessed December 3, 2016. <http://www.solardecathlon.gov/about.html>.

the environmental and economic benefits of clean energy products and designs. It helps train students for the clean energy workforce, while providing a unique outlook into integrated design, as it is crucial in the project for there to be collaborations between the engineers, architects, science majors and other fields pertaining to marketing and communication.

In order to judge and rate these prototype homes, the Solar Decathlon has divided the competition into 10 contests each worth 100 points. Last year, 6 categories were decided by jury, while the remaining 4 were strictly measured. One thing to note for 2017 was that there was a new innovation category that encourages more daring and experimental designs. Figure 1.1 shows the juried contests, while Figure 1.2 shows the measured.

Juried		
Contest Number	Contest Name	Points
1	Architecture	100
2	Market Potential	100
3	Engineering	100
4	Communications	100
5	Innovation	100
6	Water	100
Juried Total		600

Figure 1.1 Solar Decathlon Juried Contests. The 6 contests rated by a panel of jurors (NREL: 1)

Measured					
Contest Number	Contest Name	Points	Subcontest Name	Points	Tasks or Periods
7	Health and Comfort	100	Temperature	55	588
			Humidity	25	588
			Indoor Air Quality	10	320
			Air Tightness	10	1
8	Appliances	100	Refrigerator	8	766
			Freezer	8	766
			Clothes Washer	10	5
			Clothes Drying	20	5
			Cooking	12	6
			Hot Water	42	14
9	Home Life	100	Lighting	30	30
			Home Electronics	10	20
			Dinner Party	10	2
			Game Night	5	1
			Commuting	45	5
10	Energy	100	Energy Production	60	-
			Energy Value	40	-
Measured Total		400			
Total		1,000			

Figure 1.2. The remaining 4 contests that are measured directly (NREL: 1)

Each category must be carefully considered in the design, because typically the difference between 1<sup>st</sup> and 2<sup>nd</sup> place is 1 or 2 points out of 1000. In 2017 the rewards were between \$125,000 and \$300,000 for 1<sup>st</sup> through 4<sup>th</sup> place. Meanwhile, 5<sup>th</sup> or lower gets the same reward of \$100,000 for simply completing the project.<sup>2</sup>

For 2017, the competition was held Denver, Colorado. The strict schedule and rules significantly impacted the University's design. The project had to be shipped to the site and where the team was given 2 days to register and stage. Afterward, 10 days were given to actually construct the house, severely limiting

<sup>2</sup> NREL. "Solar Decathlon Contests." Solardecathlon.gov. Accessed December 4, 2016. <http://www.solardecathlon.gov/2017/competition-contests.html>.

certain construction methods from being done on site, like concrete for example. Typically, teams ship pre-fabricated modules that can fit on trucks. The modules use a crane to connect the segments of the house together. Only a few teams have done a panelized flat packing strategy, where standardized pieces allow for fast assembly of the house on site. After construction, the jury walkthroughs and measured tests took place. Once completed, the house was safe for the public exhibit. In the past there have also been popularity scores based on public perception. The last step was disassembly and then re-shipping. Maryland's ReAct home was able to win 2<sup>nd</sup> place in the innovation category, and 2<sup>nd</sup> place overall. The summary of this demanding schedule is outlined in Figure 1.3.



There are several other rules that limit the design specifically for the completion. Since the house must be disassembled, which has several design implications on its own, the house must be raised up about 2 feet. The result is that every house has decking and ADA approved ramps to get up. No stairs are allowed. Other rules that result in some oddities are that all the power must be generated through solar, as it is the Solar Decathlon. This means no use of wind or human mechanical energy to directly power anything tied to the grid. There are other restricting rules, but the point is that this thesis explores some of the potential for UMD's ReAct design to fit into a more realistic scenario, where there will be opportunities to actually dig into the ground or power the house through other means. What is interesting however, is that the need to quickly assemble and disassemble the home is something that could still have some real-world applications and benefits if implemented to some degree.

### Summary of the Team's Previous Design Work

The process to reach the final ReAct concept took place from the Spring of 2016 to the Fall of 2016. The theme of ReAct is that the design of the home is one that is flexible and can react to various user inputs and climate variables. It is important to understand the background of what went into the design because the ReAct submission was only one version, while the work that led up to it actually considered several other design options. These other options tie into the name for the final design ReAct, which implies its ability to respond and react to these different variables and circumstances.

Knowing ahead of time that tribes like the Apache in Bylas Arizona, as well as other tribes like the Nanticoke, were interested in buying Team Maryland's house concept for the Solar Decathlon certainly impacted the way the original team of 8 architects designed the first prototypes. Some of the following work and diagrams are attributed to those 8 architects, including the author. As will be analyzed later in Chapter 4, the history of the Apache has been one of a flexible, adaptive people with traditions like intergenerational families and mobile lifestyles. Therefore, the team aimed to achieve a wide range of variance in concepts to avoid monotony. One of the methods was to study the past decathlon submissions, and divide our schemes based on the most common "partis", or building shapes, like bar, shifted bar, U-shaped, L-shaped etc. Eventually, a system of typologies was created with 4 main types which ranged from simple to complex, as well as most efficient volume to surface area ratio, to least efficient. This long process has been summarized in Figure 1.4 by the author.<sup>3</sup>

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<sup>3</sup> Courtney, Christopher. "Diagram of the four major typologies." Chart. In Work from Fall 2016.

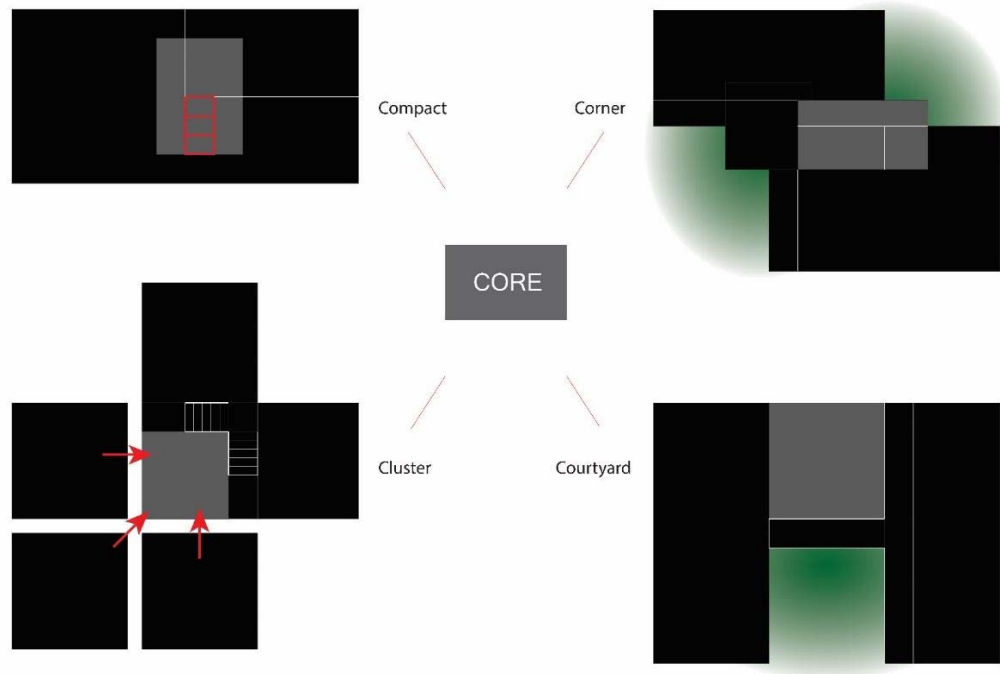


Figure 1.4 The four main shapes that a 1000 square foot house could take on.

(Christopher Courtney)

Although a sphere is the most efficient surface area to volume ratio, for the purposes of construction, the bar building was the most practical building form. This first version is called compact, as the ideas that revolve around it imply simplicity and efficiency of living. A few of the themes of the compact scheme are shown in Figure 1.5, which summarizes only a few of the many ideas that went into the final project submission of the Fall 2016 semester by the author and



Steven Pasquerello.<sup>4</sup>

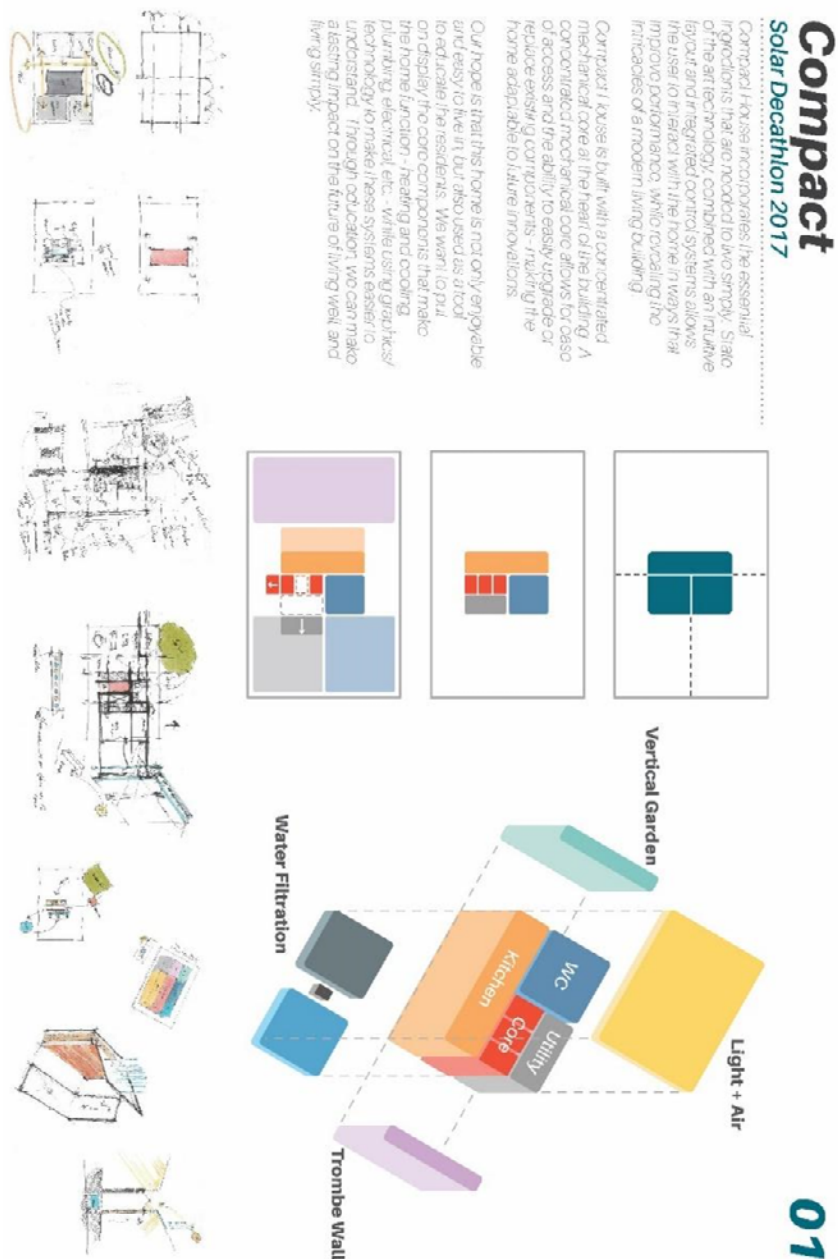


Figure 1.5 The main themes of efficiency and simplicity in the compact scheme (Christopher Courtney and Steven Pasquerello: 1)

<sup>4</sup> Courtney, Christopher, and Steven Pasquerello. "Compact: Solar Decathlon 2017." Chart. In Fall 2016 Final Project Submission, 1.

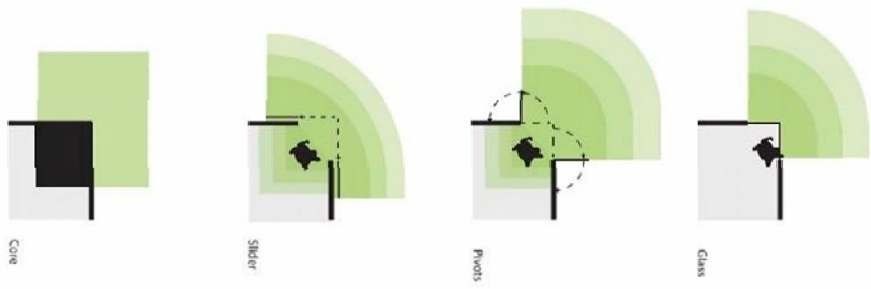
The 2<sup>nd</sup> most efficient shape was the corner scheme, named because the various shifts and slides to the bar create more than 4 corners like in the compact scheme. The ideas then revolved around what opportunities does the corner have to relate to the landscape in 270 degree views. It also stressed flexibility of moving walls that could adjust how the indoors related to the outdoors. Because the design stressed the importance of the outdoors, vegetation and hydroponic gardening was carefully configured throughout the site. Figure 1.6 shows the main concepts underlying the corner scheme in the final project submission by Tui and Hao Ming.<sup>5</sup> The corner scheme was assimilated into to the compact.

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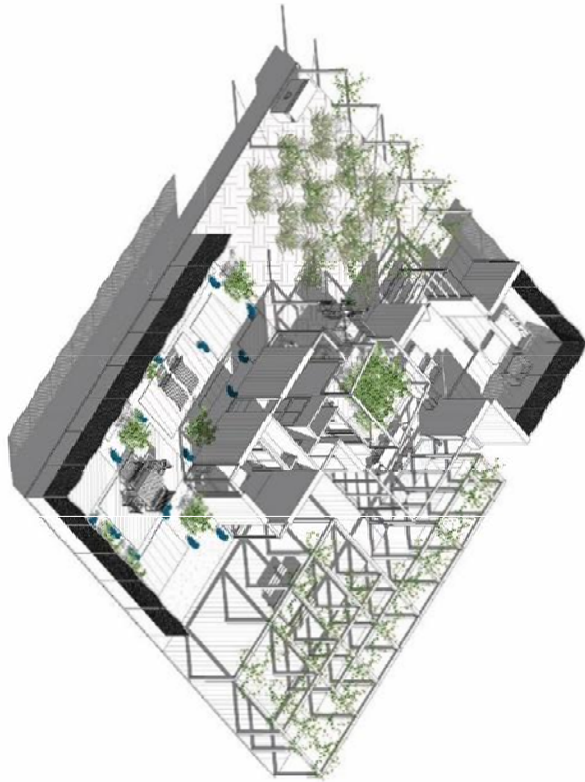
<sup>5</sup> Tui, and Hao Ming. "Corners: Captivating Environment." Chart. In Fall 2016 Final Project Submission, 2.

# Corners

Captivating Environment



Axonometrics



Featured Gardens

02

Figure 1.6. Themes of indoor and outdoor flexibility in the corner scheme (Tui and Hao Ming: 2)

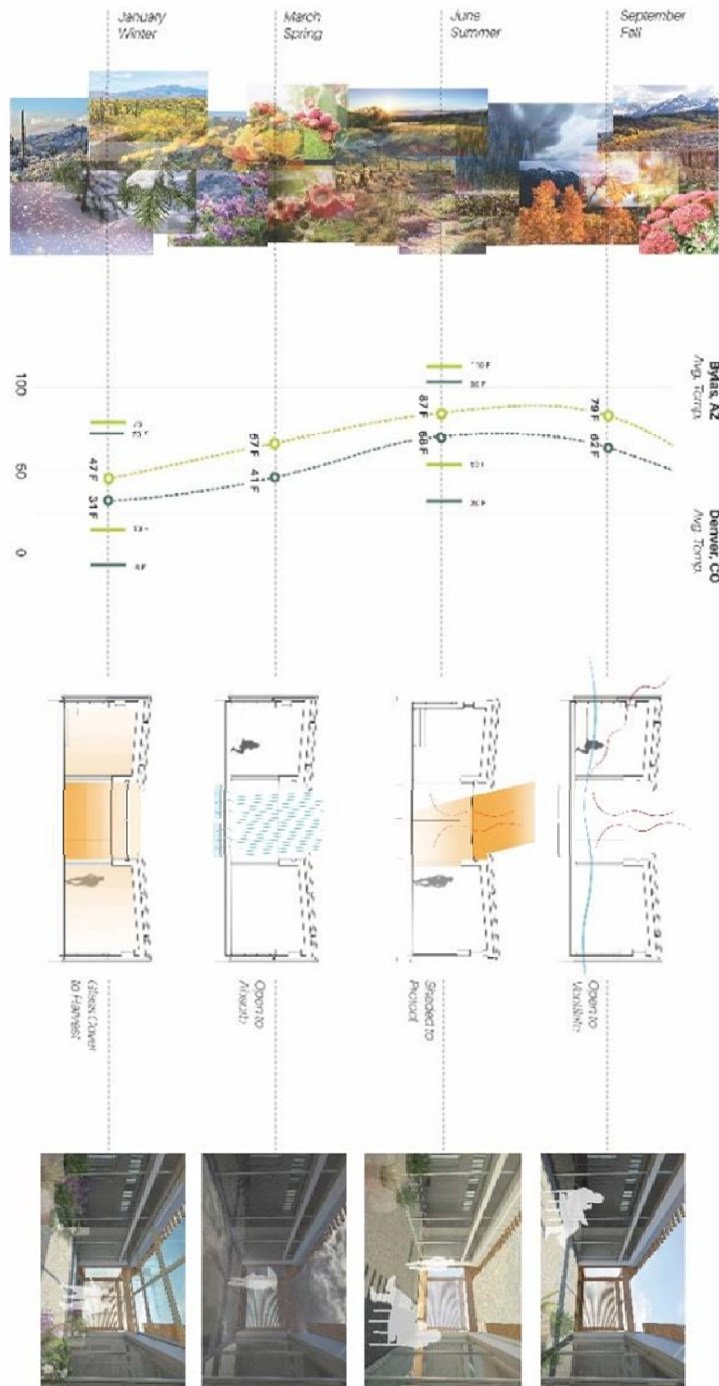
After this point, the shapes become very inefficient cost wise, but gain many other unique advantages. This is where the courtyard scheme comes into play. The courtyard is a unique shape in that it is implied that the driver of its shape is actually a negative space, or void in the center. If more square footage is used, a complete donut shape could be achieved, but in this case the outdoor courtyard is surrounded by only 3 sides. The ideas revolving around the courtyard shape included private outdoor space, and passive heating and cooling strategies to match the seasonal and day night swings of the desert climate. It is also notable that very few Decathlon entries in the past used the courtyard shape. The courtyard ideas are summarized in Figure 1.7. from Maryssa Timberlake and Erin Barkman's final project.<sup>6</sup>

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<sup>6</sup> Timberlake, Maryssa and Erin Barkman. "Seasonal Response: Adaptive Courtyard." Chart. In Fall 2016 Final Project Submission, 2.

# Seasonal Response

## Adaptive Courtyard



02

Figure 1.7. The courtyard can adapt to different weather conditions and store heat (Maryssa Timberlake and Erin Barkman: 2)

The least efficient shape, but at the same time most flexible one, is the cluster concept. The shape started as the idea of any building form that had two or more separate enclosures that one would have to walk outdoors to get between, something that is not necessarily a problem in warm climates. But shape is almost shapeless, as it is more of a concept revolving around maximum flexibility. The idea is that one part of the house, where the utilizes are, would remain static, while the other, more empty spaces such as bedrooms could essentially plug into the central power and utility space. The options of arranging the different rooms around the sort of central nervous system of the house plays well to a house that can grow in an upward, almost spiral like fashion. This concept is shown in Figure 1.8. from the final project of Pedro Sanchez and Boyu Li<sup>7</sup>

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<sup>7</sup> Sanchez, Pedro and Boyu Li. "Cluster: Versatility and Flexibility." Chart. In Fall 2016 Final Project Submission, 1.

# Cluster

Versatility and Flexibility



**Cluster :**  
It is a **building construction system** that uses **prefabricated structures** to build as an **ensemble home**

A community of cluster houses can start their home with a simple kit of parts made out of **tight gauge steel structure frame or panels**. An essential cluster home has a highly **compact core**, that provides means of flows, services and organizations. **Modular spaces** can be later added as needed, such as living/dining room, studio/bedroom/ guest room on the **chassis of the house** using the **same parts**. Family from a cluster home can enjoy the dynamism and flexibility of the house.

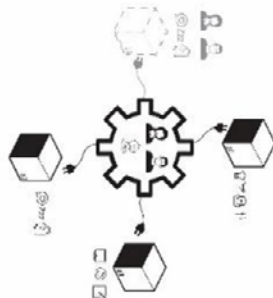
**Home concept:**

Adaptable spaces  
Multifunction spaces

Work at home  
Work / Live life style

Potential for growing family

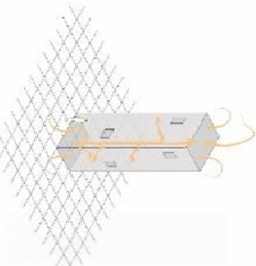
In-law suite  
Resilient home



Chassis



COMPACT VERTICAL CORES



CIRCULATION



POROSITY



EXPOSE AND ABSORB



Figure 1.8. The plug and play and upward expansion concepts of the cluster (Pedro Sanchez and Boyu Li: 1)

These four concepts were the result of a semester's worth of work from 8 students, members of Team Maryland. The most important unifying themes, concepts, and technologies were consolidated into an organizing framework and structure. The idea that the four main shapes could share something consistent theme wise was the challenge. This is when the concept of the "core" was thoroughly analyzed. While the idea of consolidating the bathroom, laundry, kitchen and mechanical room into one efficient space, had been experimented here and there in a few of the previous scheme, the idea that there would be an efficient, central core, no matter what the exterior shape of the building, was new. Figure 1.9 from the Summer 2016 shows the early concept for how the core of the building could remain constant, while the exterior shape could grow to any size or shape, essentially starting as the bar, or compact scheme, and growing into the courtyard scheme.

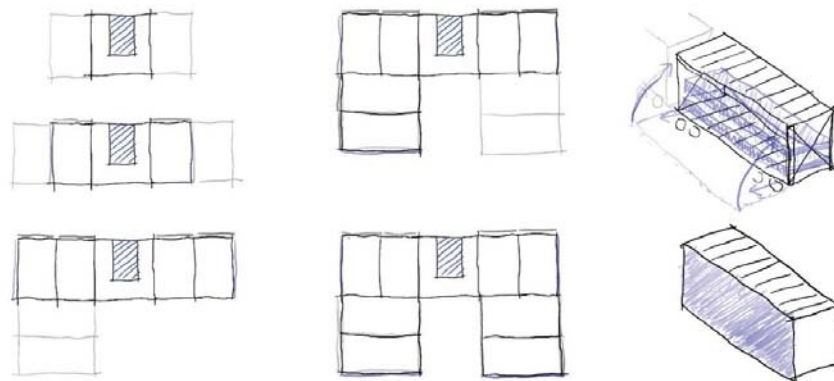


Figure 1.9. Concept of a consistent core, with flexible exterior expansion.

(Christopher Courtney)



Always in the background is the idea of how the house could aggregate in a community setting. With enough space between each house, even if they decide to grow in the future, the solar envelopes for each house won't overlap. Also, if a central space is left aside where no one is allowed to expand to, opportunities emerge for communities gardens or shared composting/water filtration to emerge. The early concepts for this are shown in Figure 1.10



Figure 1.10. How the house could grow without compromising solar envelopes.  
(Christopher Courtney)

A part of the summer's work was also summarizing the most interesting and innovative technologies of the four schemes, in order to pick the best for the final design, but also keep some of the unused technologies as customizable options for other versions. Some of the most important technologies that made it to the final ReAct scheme are hydroponic gardening, panelized walls, solar drying

Figure 1.11. A list of the more innovative features and unifying themes  
(Christopher Courtney)



## The Direction and Goal of ReAct (What is it trying to solve)

The last part of the summer was aimed at creating a matrix of options. In this case the design options were geared towards the courtyard scheme and its utility core options. A design by advantages method was used to determine which specific arrangement of the laundry, bathroom, kitchen and mechanical room was most efficient, comfortable, practical and neat. With the pluses and minuses of every option considered, only the best arrangement would be objectively chosen by the team for the next semester. One example of one particular core arrangement and its pluses and minus is shown in Figure 1.12. These options were again always considering the possibility of growing the house vertically. To get an understanding of how significantly different the versions can get, the next design, Figure 1.13, shows a core with an east west kitchen arrangement. Finally, to understand the different types and sub types of arrangements, a matrix of several options in one chart helps to demonstrate the organizing logic as shown in Figure 1.14.

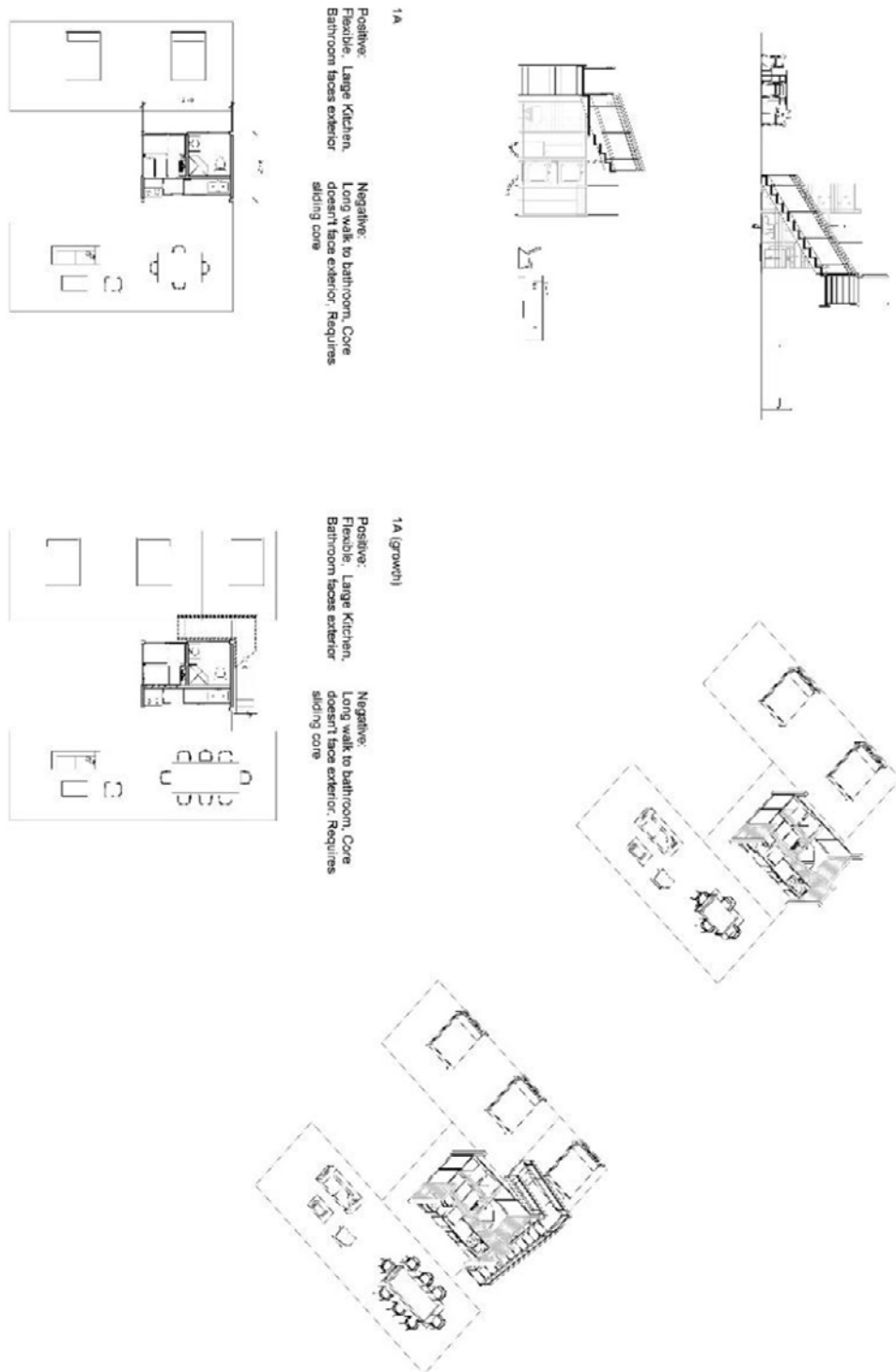


Figure 1.12. Version 1A for the courtyard scheme with a north south kitchen  
(Christopher Courtney)

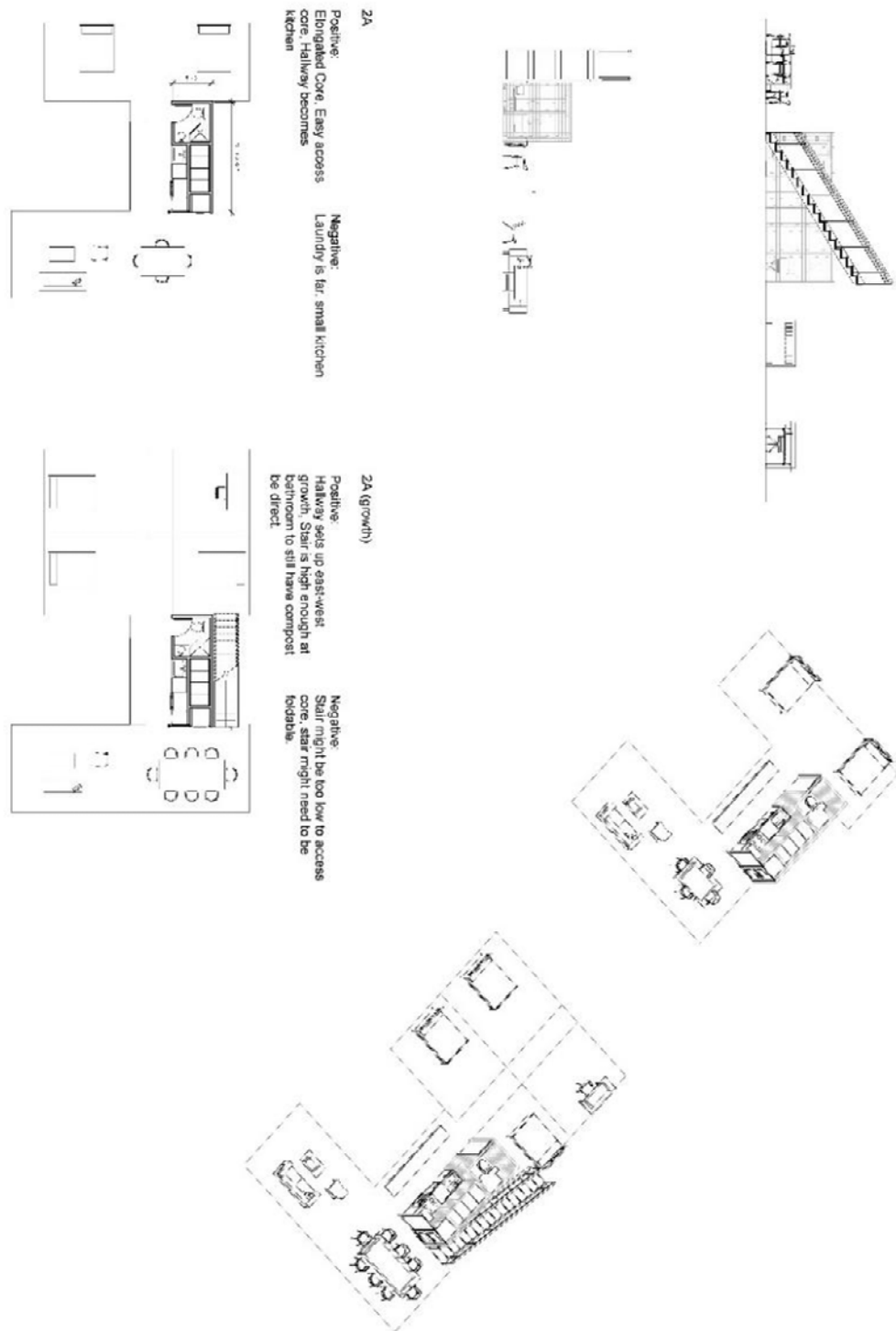


Figure 1.13. Version 2A with an east west galley kitchen arrangement.

(Christopher Courtney)



Figure 1.14 the master matrix for every major core arrangement scenario.

(Christopher Courtney and Pedro Sanchez)

This same process of listing every options and then applying a design by advantages scenario can be applied to other changeable variables in the house such as the exterior shape or wall material. This is where the work pertaining to the past decathlon studies ends, and the work pertaining directly to thesis begins, as this concept of adjustable variables of the home based on user input is the crux of the issue.

## **Chapter 2: Program**

One might question if this client input-based system of deciding the program addresses any actual problem, or if the way things have traditionally been done with vernacular architecture is acceptable. Usually, when designing homes in mass, one designer is in charge of the whole look of a neighborhood. This can result in neat consistency for things like urban settings, but can also arguably take away from those that desire individuality. Some firms have responded to this, where one sees in suburb settings, designer employ cheap maneuvers to vary each house slightly, with little thought behind why. Sometimes the entire house is mirrored, the roof style changed, or color of the window shutters varied. While sometimes it looks appealing to outsiders if a neighborhood looks consistent, this thesis explores the idea that there can still be strong underlying consistencies while simultaneously giving the client and user the power to make these slight style and programmatic changes to fit their lifestyle. Usually, those that hire an architect spend a lot of extra money to customize their house. If it was possible, however, to map out ahead of time, the thousands of options users are most likely to pick from within this region and climate zone, clients could have the sense of power over their own home preferences without having to pay extra money. The tool upon which this thesis explores user customizability is a smartphone application.

### **House Scale Program Necessities and Options**

Before diving into how the app would work, the groundwork for the basic programmatic needs of any house, as well as the more optional additional features

that could be added must be explored. Regardless of location and climate, several utilities and programmatic spaces are found in every house. The program of a house, regardless of the size of each room or space, has traditionally been at least one bedroom, bathroom, laundry, kitchen, dining, living, and mechanical room. There are of course exceptions like with dorm or efficiency apartment living, but for the purposes of this thesis, the idea will revolve around the house. In this case, the bathroom, laundry, kitchen, and mechanical room are kept in a close knit, but customizable unit for purposes of efficiency. The next tier of programmatic spaces is common, but more optional and include, storage, garage, office, recreation room and outdoor patios. Often spaces like this are just flexible, empty rooms that the owner can furnish in any way they please. And finally, if a large enough house, an additional tier of options could include things like indoor gardens, greenhouses, wine cellars, mini bars, composting gardens, exercise rooms, or theatres. Which program is needed, and how much of it is ideal, is something that the user might decide based on their family size and structure, keeping in mind that in the Apache culture, it is common for intergenerational families to combine old and young in one household. Figure 2.1 displays the general concept of potentially inputting your family size into smartphone app in order to see options best suited for the scenario.



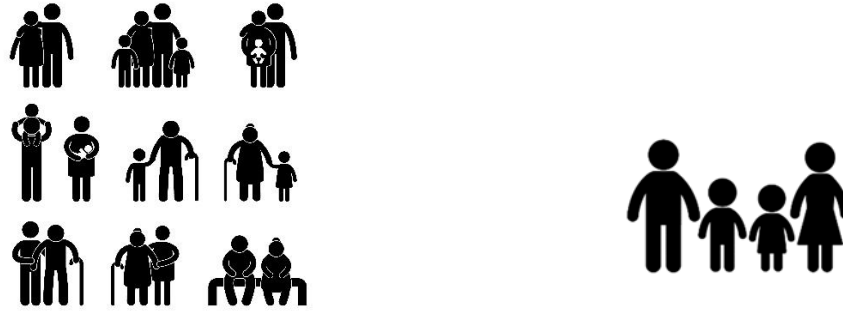


Figure 2.1. The needs of the user will depend on the size of their family (Clipart Kid)

It is possible to imagine a scenario where the pragmatic options and flexibility are dictated based on the possibility of future growth or shrinkage, as in the case of a couple growing a family, or a sibling moving out.

### The Adaptable Variables of the House

While program is perhaps the most important variable a client would want to be able to adjust, there are several others pertaining to the style, aesthetics, utilities and outdoor features that they may or may not be interested in controlling. What has evolved over time when describing these essential components of the house is a sort of human analogy. The parts and systems of the building can be related to the body parts and systems of a human to better correspond the building terminology to something more relatable for a client. As such the main parts of a house are broken down into 5 categories, the heart, body, skin, landscape, and community. While not everyone will understand, or even want to be able to change some of these variables, there is larger concept surrounding the reasoning behind distinguishing every variable of a house where some changes will be

automatically dictated or limited based on the location, climate, and local building codes. If the design to be adaptable to any region, it needs to consider enough options ahead of time to ensure the house will actually work as intended.

The heart pumps blood in much the same way that a building has utilities and various systems to distribute things like water and air throughout the building. The adjustable variables pertaining to the category, heart, consists of the core arrangement (kitchen, bathroom, and laundry, mechanical), the systems (plumbing, HVAC, electrical), and the appliances (dishwasher, oven, sink, fridge, etc.).

The body is the various functions and spaces that surround and depend upon the core utilities. These are generally empty spaces that are furnished later, but also includes the structure that holds it upright. The body category consists of the program (bedroom, living, dining, office etc.), the structure (columns, beams, load bearing walls, etc.) the distribution of systems (the ducts, pipes, and wires extending from the core) and the interior finishes (wall materials, carpets, lighting, fixtures, etc.).

The last category pertaining to the house itself is the skin. This category of variables is about what contains the building, what insulates it from the outdoors, and how it helps the inside maintain a homeostasis. The skin can also be seen as a sensory element in a house, when it comes to reading weather data or collecting sun energy. The variable within skin include, walls, floors, roofs, windows, doors, materials, and collectors like PV panels.

The fourth category breaks outside the boundaries of the house and is therefore called the landscape. The land and outdoors are typically seen by humans or plants as the source of our nutrients and energy. It is much the same way in buildings now that most are powered by electricity. In this sense, the landscape category includes the flexibility of adjusting variables such as the water collection and filtration methods and various plant species grown outdoors (food, shade, climate control, aesthetics etc.).

The fifth and final category is the community. The houses need to be arranged in a logical way where the rights of other are not negatively impacted people's choices, like in the case of solar envelopes and air rights. The arrangement of the homes can also dictate *how* people would like to live, so it is important that people can choose to live in different zones within the masterplan that range from individualistic, to community oriented living. The variables within the community category include expansion/aggregation (solar envelopes, density) and desired community vs individualistic functions (gardens, composting, and water filtration, etc.). With the help of an urban planner, the house would be integrated with a master plan design of the community.

These 5 categories include almost everything that could change in a house, but again, it is not necessarily the case that the user would even want to change all these options. That is why it is important that within the app, the client will be able to decide early on the process whether they want a choice between a few popular options, or would actually like to micro manage every decision, potentially as a

family. But now that all the variable have been laid out, the methods and user interface of the app can be explored.

### Smartphone App Concept – Customize Your Own Home

When dealing with so many variables, it is crucial that the app has an organizing structure upon with variables can be limited and reduced through a series of steps. A house can be dictated step by step from heart to community, or several steps skipped or left as default. The first step will be to decide which zone in the master plan is best suited for the client via a survey method which is very commonly found online. The other method when it comes down to the details of the program and house features will involve a live virtual model of the house that changes as the user swipes through various variables.

Starting with swiping variable method, a simplified example can help explain the process of sorting quickly and efficiently through several variables. Instead of thinking of variables like program, materials, appliances, and plant species, think of a basic thing like text. Text can be changed based on a number of variables such as size, font style, color, number, word, language etc. While most user interfaces have drag down boxes to select options, it might not be the best option when dealing with a live, updating house. Figure 2.2 shows how the user could select the option to sort by 1 variable, number, while others such as font style, color, and letter remain constant.

1 variable: number

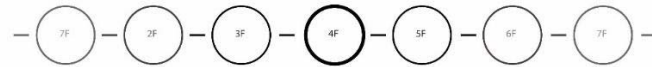


Figure 2.2. Selecting by 1 variable at a time, number. (Chris Courtney)

This choosing by 1 variable at a time however is slow when dealing with many options. It might be advantageous if another variable is added along the Y axis so that one could quickly go back and forth between the options and combinations until it looks right. Figure 2.3 uses 2 axes to adjust either letter or number. Figure 2.2 shows an example of a basic 2-dimensional sort of matrix where options are changed 1 variable at a time, and the option that is being lit up changes in the live model. The result is always in the center, updating live. The way this would work however is via a sliding motion that drags all of the options over until released in the position desired as shown in Figure 2.4.

2 variables: number + letter

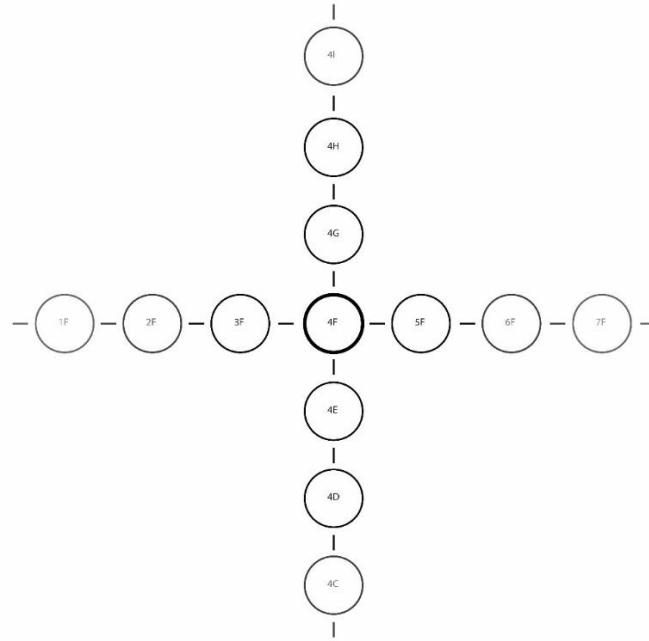


Figure 2.3 Selecting by 2 variables at a time, number and letter. (Chris Courtney)

2 variables: number + letter

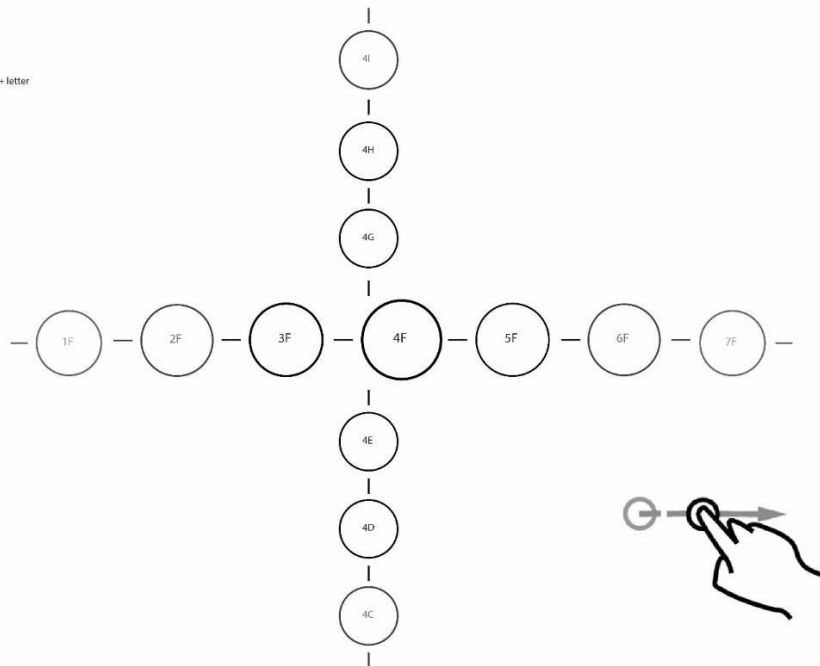


Figure 2.4 Method of sliding the desired options over until relocking in the center  
(Chris Courtney)

After sliding, the desired option locks in the center and reupdates the result. It essentially changed the option from 4F to 3F by sliding from left to right, resulting in Figure 2.5

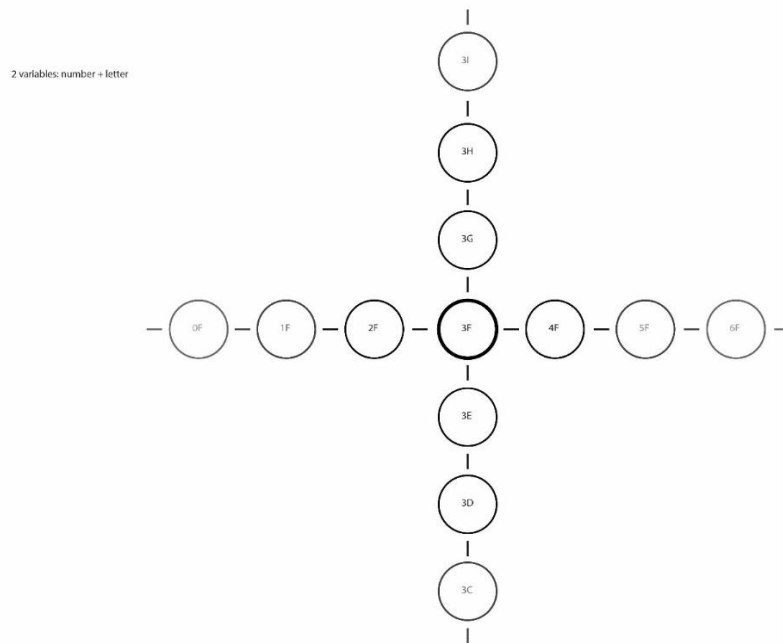


Figure 2.5 The result of sliding a new option into the center. (Chris Courtney)

One can imagine, however, that the interface wouldn't be limited to just 2 variables at a time. Depending on how big the screen, 3 or 4 could be added so that several variables that relate to each other can be seen all at once, like in the final example of Figure 2.6.

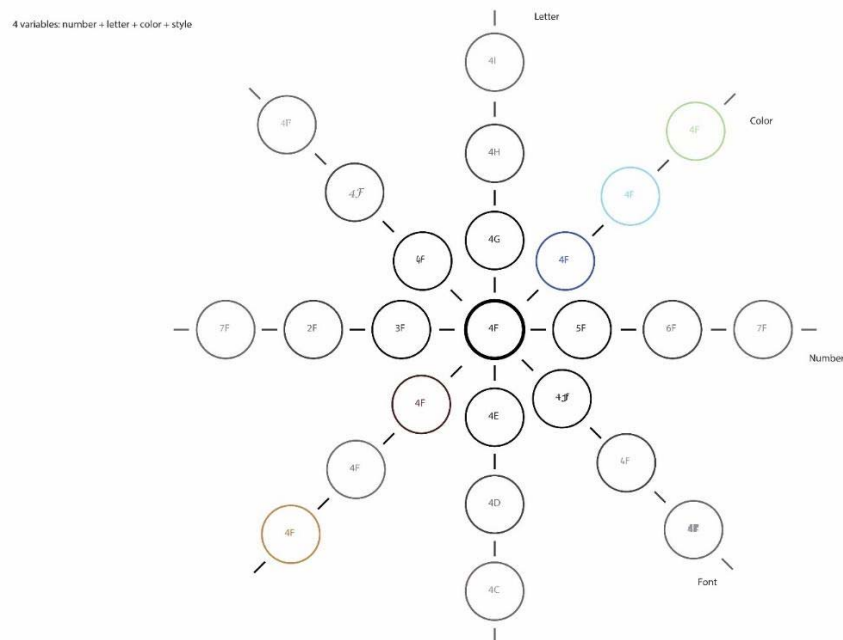


Figure 2.6. Selecting by four variables at once, letter, color, number, and font.

(Chris Courtney)

While it may be too complex for a smartphone to sort more than 4 variables at a time, a website could easily handle 5 or 6 on a large screen. Often, when dealing with parametric designs, it helps to be able to adjust variables back and forth until things look right. In the case of the house however, it is going to be whether or not the house feels right to the homeowners and their needs. Figure 2.7 shows how this simplified example of text could apply to a situation in the house where a user is changing the interior wall material to their liking, as seeing the change happen in the virtual model.



Edit by 1 variable:

## Wall Material

Exterior Walls	Adobe	Rammed Earth	Steel	Wood	Core Wall Material
----------------	-------	--------------	-------	------	--------------------

Partition Walls	Translucent	Dry Wall	Steel	Wood	Aluminum
-----------------	-------------	----------	-------	------	----------

Core Wall	Steel	Tile	Slate	Wood	Concrete
-----------	-------	------	-------	------	----------

Outdoor Walls	Translucent	Rammed Earth	Green Wall	Wood	Concrete
---------------	-------------	--------------	------------	------	----------

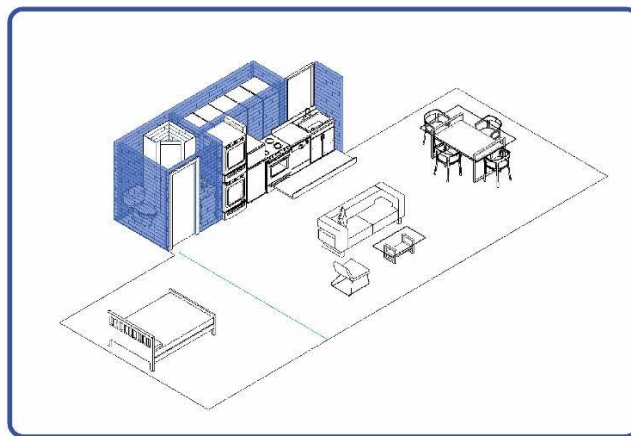


Figure 2.7 The walls can light up when they are being changed by the user. (Chris Courtney)

There is a process where if the user is overwhelmed by the number of options, they can limit the variables ahead of time via a survey questionnaire.

These days, surveys are found on websites where scores can be attributed to certain answers than tallied at the end to determine the options that closes match their preferences. For example, “what personality type are you” is a common online survey. For the following figures, a survey was created by the author, using the author’s original images, but with the help of Playbuzz’s online survey generator.<sup>8</sup> Figure 2.8 for example asks an important question about the size of the kitchen. Some people don’t need large kitchens, but for some it is important.

The image is a screenshot of a Playbuzz survey interface. At the top, the title "Customize your home's utilities within the 'core'" is displayed. Below the title, it says "Created by SabreChris18 on November 7, 2016". A progress bar shows 9 steps, with the first step highlighted. The main content area features three vertical diagrams of kitchen layouts, each with a different number of cabinets and appliances. Below these diagrams is a question: "How big does your kitchen need to be?". Underneath the question is a table with three options: "Small (less than 9ft)", "Medium (9 - 12ft)", and "Large (greater than 12ft)". The "Small" option is currently selected and highlighted in blue.

How big does your kitchen need to be? *
<u>Small (less than 9ft)</u>
Medium (9 - 12ft)
Large (greater than 12ft)

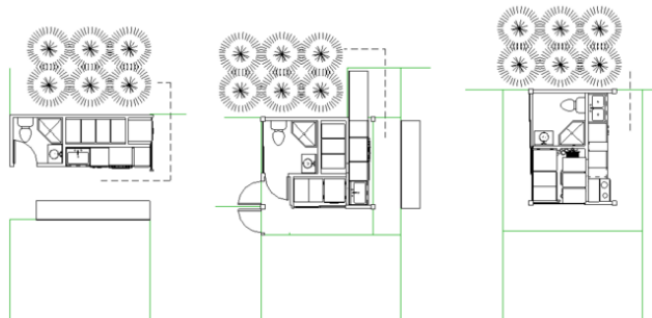
<sup>8</sup> Courtney, Christopher. "Customize your home's utilities within the 'core'." Playbuzz.com. November 09, 2016. Accessed November 20, 2016. <https://www.playbuzz.com/sabrechris1810/customize-your-homes-utilities-within-the-core>.

Figure 2.8 A question that considers the size of the kitchen. (Chris Courtney via playbuzz.com)

### Customize your home's utilities within the "core"

Created by [SabreChris18](#) on November 7, 2016

< 1 2 3 4 5 6 7 8 9



How close does the kitchen need to be to the compost garden?

Far

Somewhat close

Close

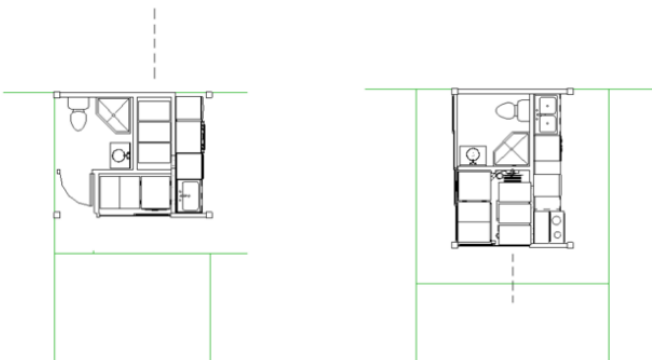
Figure 2.9. A question pertaining to the proximity of the kitchen to the compost. (Chris Courtney via playbuzz.com)

In Figure 2.9, a question is asked about how close the compost should be to the kitchen. Some may want it close for practical purposes, but others may want it far away from reasons like smell.

## Customize your home's utilities within the "core"

Created by [SabreChris18](#) on November 7, 2016

1 2 3 4 5 6 7 8 9



Is it important that a mechanic is able to access the mechanical room from the outdoors, without having to enter your house?

Christopher Courtney

Yes No

Figure 2.10. A question about serviceability to the mechanical room. (Chris Courtney via playbuzz.com)

The 6<sup>th</sup> question in the survey asks if it is important that a mechanic be able to repair the utilities in the mechanical room without entering the house. This is a nice feature, but has implications for how the rest of the features of the core can and cannot be arranged now that the mechanical room must face the exterior of the house.

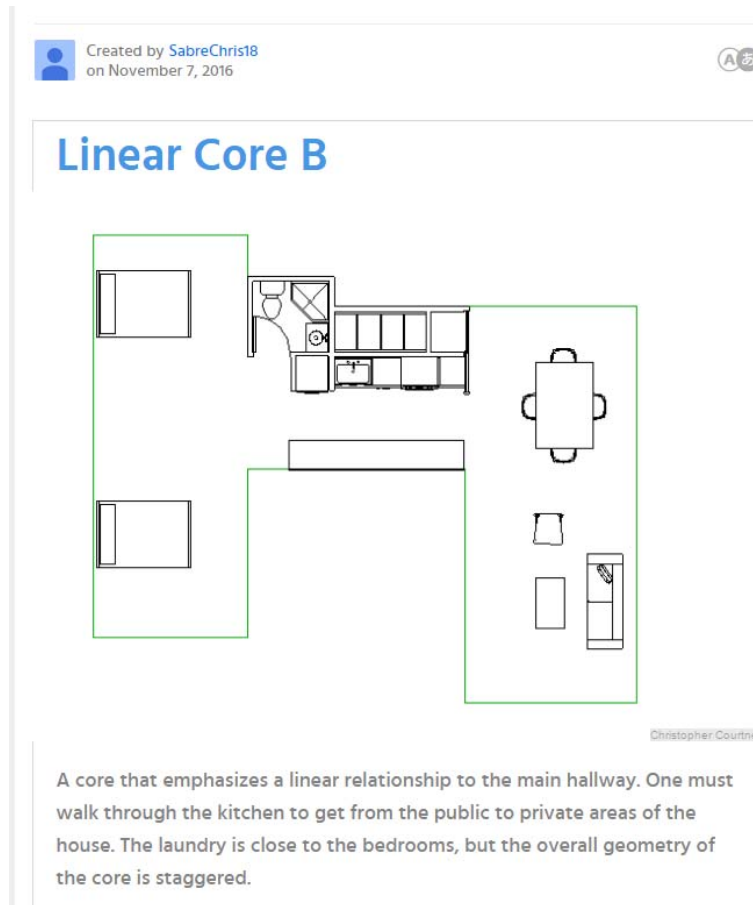


Figure 2.11 The final result and description of the core arrangement most suited to the user's answers on the questionnaire. (Chris Courtney via playbuzz.com)

This is a very fast way to dictate the proximities and adjacencies of the program, in this case the arrangement of the components in the core for the courtyard scheme. The nice thing about this sliding app + survey system is that the user can essentially limit the number of options by first filling out a survey. The number of options that are no longer available based on the user's survey answers could visibly fade out as shown in Figure 2.12.

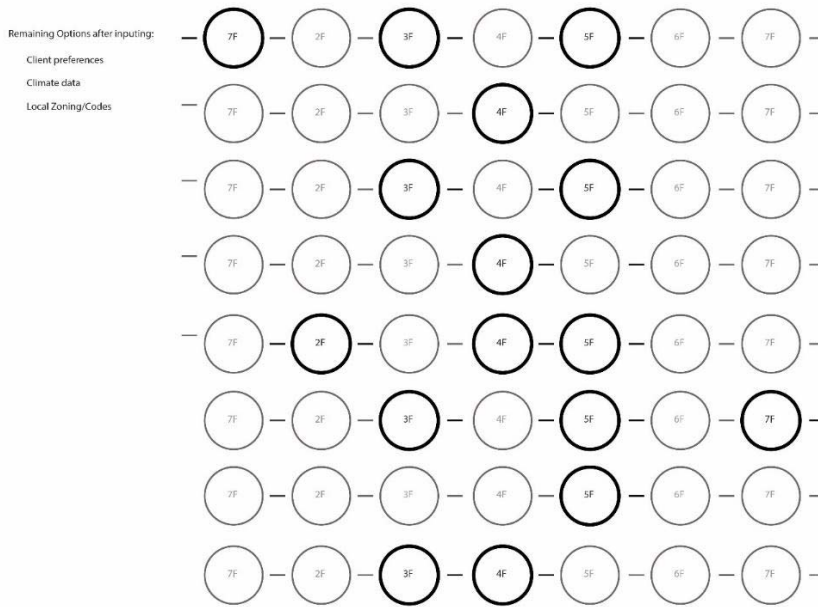


Figure 2.12 Some options are no longer available after filling out the survey.

(Chris Courtney)

The client can go back and forth between whichever methods they so desire, basically adjusting the level of customizability. They can answer some question, then swipe to make some custom changes, then go back to answer questions, and repeat until the house meets their needs. This way, a thousand or more homes in the community can be personalized in a short amount of time, and the client will feel a more intimate connection to the house they helped create. At the same time through this survey and variable method, the client will be zoned to the most appropriate region of the master plan based on preferences, and will not have to worry about whether their decisions will negatively impact the rights of others nearby.

### Site Scale Program Necessities for Any Generic Site

The last component to the program is dealing handling of the masterplan phase of design. This is something that no matter how many variables are considered, no design can pre-exist for every site in the world. There are just too many variables and factors, and the layout of a master plan could not fit into an adjustable app scenario. When dealing with site, a perfectly customized, fully designed master plan must be done by architects and planners who can research the history, culture, codes, and climate of the area, and layout the grid, zones, and program appropriately. This thesis will therefore design the typical home to be placed in the master plan of Bylas, Arizona, and then see how after that is determined, how the house itself can still work in the masterplan because of its ability to swap systems and change insulations to be better suited to the climate and meet the building codes of the state and county. While a large database of wall materials could be in the apps data, when applied to the limits and constraints of the masterplan, codes, and climate the number of options will rapidly decrease. The masterplan then, will need some basic programmatic and functional considerations pertaining to things such as density, solar envelopes, and air rights.

Some basic considerations in the masterplan will revolve around how the zones should be organized. Often, common sense prevents functions like industrial from being placed right next to schools or hospitals. For the purpose of the house, these zones will be set up based on common living style preferences. A master list of Bylas' needs has been included in the current masterplan for the





includes the must haves in a community, similar to the must have items in any house.

There is another tier of more optional programmatic features that are typically seen in communities, and more often in sustainable communities. This includes things such as community gardens, shared water filtration, shared composting facilities, shared, power sources (wind, solar), cultural resources (museums, music, libraries, heritage sites), and natural land features (rivers, mountains, forests). Many of these features have to do with the benefits of having certain programmatic features be shared as opposed to individual, like in the case of water filtration perhaps.

In summary, the house will employ a highly user based customizability, but be inserted into the context of a real site and masterplan that is highly designed and specialized based on the unique history of the Apache at Bylas, Arizona.

### **Chapter 3: Precedents**

Precedents can provide a framework and context to view what has been done before, and how those strategies might be borrowed and improved upon. Customizable and additionally adaptable homes might sound new, but both ideas have been explored in different ways, sometimes even simultaneously. There are some examples throughout history of adaptive homes being well suited to their environment, as well as more recent. Examples where user customizability, differentiation, and individualism was stressed, while maintaining efficiency of

construction. The last aspect of all this is tying in the contemporary approach of applying sustainable principles to every field of design, including community planning.

### Prehistoric Indigenous Local Adaptations throughout the World

Since the main concept of this thesis is designing homes that can adapt different climates through efficient means like replaceable, swappable parts, it is appropriate to look at the history of how various ancient cultures have actually tended to create the vernacular housing type that is most suited to its environment, at least in a passive design sense. Basic decisions between either blocking or revealing the sun, and either blocking or allowing the wind, as well as other practical choices, has led each climate region towards a specific, environmentally determined solution to the problem of shelter. Figure 3.1 shows an overall view of a few of the types of vernacular architecture that has evolved and adapted over time.<sup>10</sup>

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<sup>10</sup> Marietta College. "Marietta College Biomes of the World." W3.marietta.edu. Accessed November 16, 2016. <http://w3.marietta.edu/~biol/biomes/biomes.htm>.

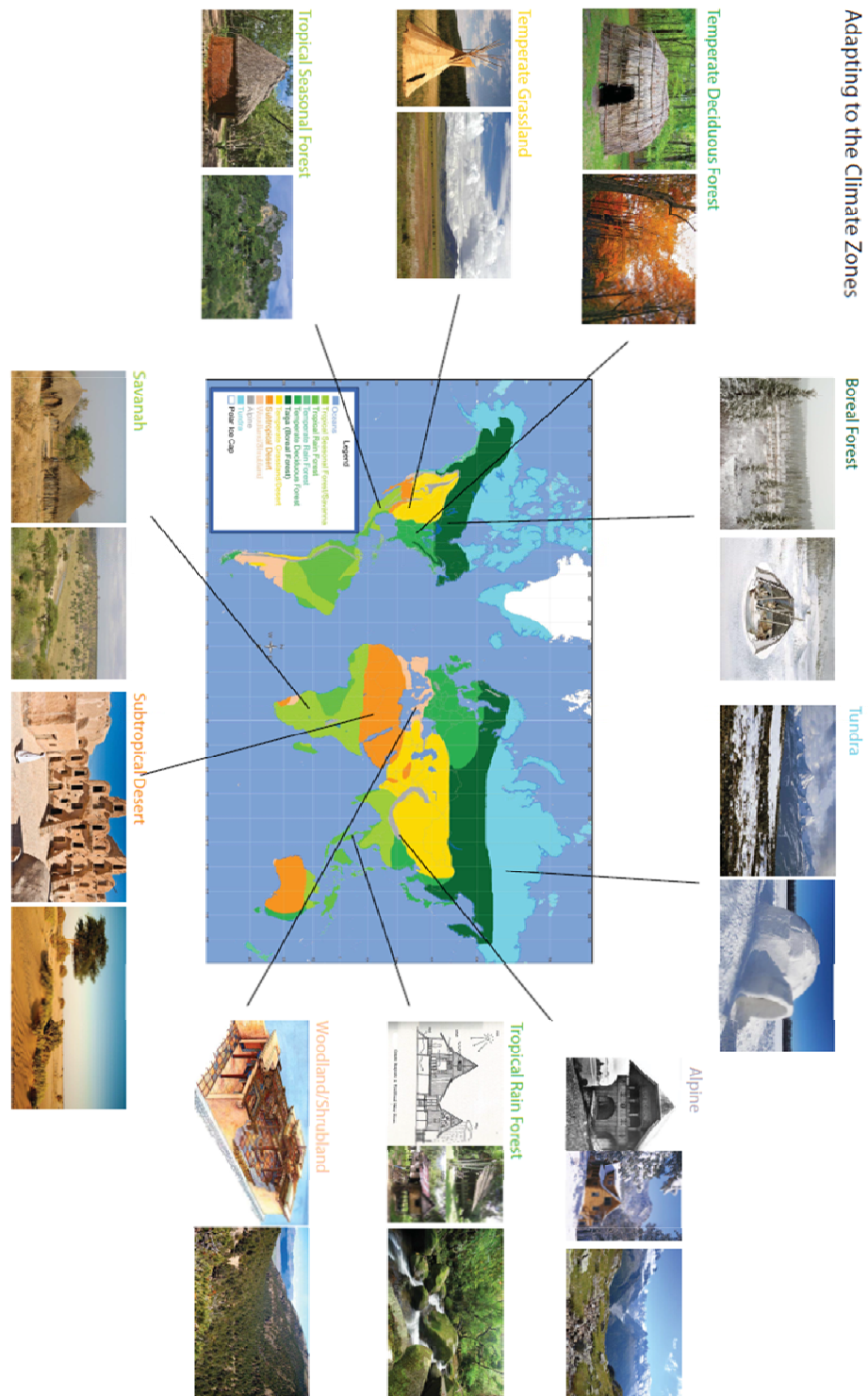


Figure 3.1 Examples of ancient vernacular architecture within its environmental context. (Base Map by Marietta College)

It is often the case that many of these primitive examples use local materials, a practice that has been abandoned after largely globalization, but is making a return in the form of the sustainability movement which has placed an emphasis on the life cycle of materials. Other lessons include the tendency for the indigenous peoples to use passive strategies, dealing with the sun, wind, and ground plane in unique ways depending on the situation and climate. Some homes are raised for ventilation purposes, while others are built into the ground for warm, cold, or insulation reasons. After the invention of agriculture, the phenomenon of cities and planning strategies emerged. Figure 3.2 lists all the precedents to be talked about in the following sections.



Figure 3.2 List of all relevant precedents to the concept of adaptable and customizable homes. (Arranged by Chris Courtney)

## Ancient Civilization's Urban Planning

A type of prehistoric structure that continued to be used even after the advent of agriculture is the wikiup, wigwam and tipi. These are mobile homes essentially, that are perfectly suited to the hunter gatherer lifestyle of following wild game.

This is the home the Apache would have used, as shown in Figure 3.3



Figure 3.3 The Wikiup and a potential style of planning. (TBH Web Team)

These mobile homes could be moved, disassembled, and rebuilt, but more often they were just left behind and rebuilt from scratch using new local materials.<sup>11</sup>

Another key feature is the hole in the top for smoke. These homes were actually quite individualistic, in that someone could pick up and leave, follow the game for a few nights, then return. The homes could also be arranged together around more ceremonial campfires at times. The idea of central chimney source of heat plays well with the potential for the core of the house to act as the center of warmth and various resources like water

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<sup>11</sup> TBH Web Team. "Wickiups: Sturdy but Temporary Structures." Wickiups. Accessed November 15, 2016. <https://www.texasbeyondhistory.net/kids/houses/wickiups.html>.

Another typology from the ancients that also stresses the central exhaust and collection hole is the Anasazi Pueblos, shown in Figure 3.4.<sup>12</sup> The pueblos used a tier method, to stack homes, thereby requiring the use of a ladder to access them. Other Anasazi homes included pit homes, which required holes for the fire, as well as light as shown in Figure 3.5.<sup>13</sup>



Figure 3.4. Pueblos, with tiered homes that require ladders for access. (Sanchez)



Figure 3.5 Light shining through the entrance to a pit house structure (Beautiful Places to Visit)

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<sup>12</sup> Sanchez, Bianca. ""Taos Pueblo" is a famous land mark New Mexico. It was built around 1350 by The Pueblo Indians." Pinterest. 2014. Accessed December 4, 2016. <https://www.pinterest.com/pin/326159197986039398/>.

<sup>13</sup> Beautiful Places to Visit. "Anasazi." Pinterest. Accessed December 8, 2016. <https://www.pinterest.com/ekraber/anasazi/>.

Light was important, as many of the homes were dug into the ground, called pit-homes. Similarly they are also known for the Kivas, dug out circular rooms for religious rituals. The Kivas were strategically placed so that each housing unit had close access to at least one Kiva, as shown in Figure 3.6.<sup>14</sup> It is also noticeable that there were planned refuse rooms and areas.

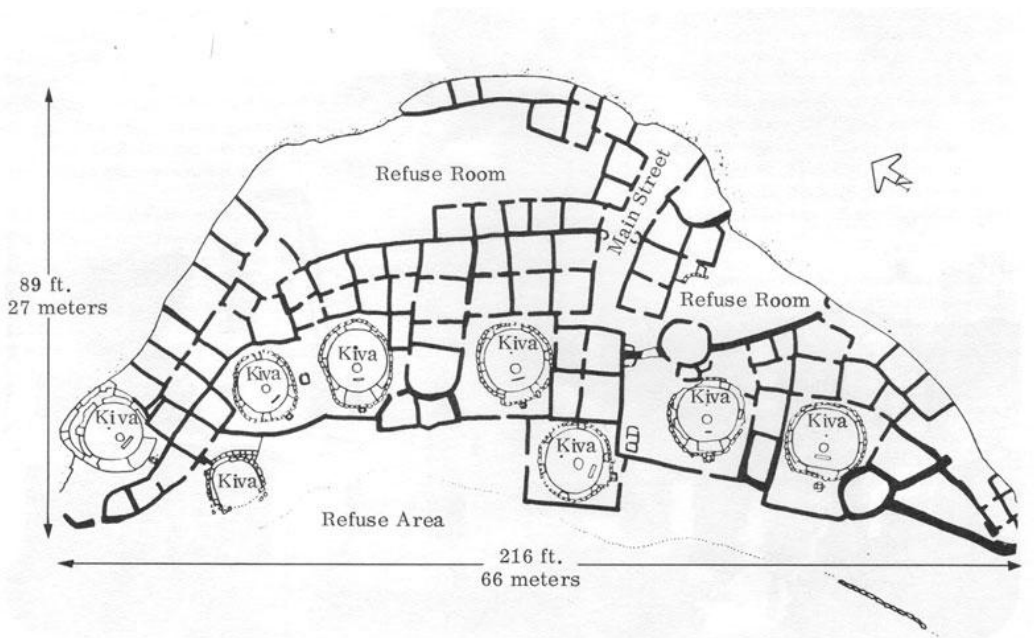


Figure 3.6. The planning style of the Anasazi Pueblos. (Fabrizi)

The last thing of note about the pueblos is that they use the local material of adobe to add thermal mass to reduce the temperature swings in the desert. The Apache actually adopted some of the Anasazi practices like adobe and at one point,

<sup>14</sup> Fabrizio, Mariabruna, and Ricardo Isidro Castiglia Says. "An Ancient Example of Cluster Planning: Pit Houses and Kivas in..." SOCKS. 2015. Accessed December 6, 2016. <http://socks-studio.com/2013/12/02/an-ancient-example-of-cluster-planning-pit-houses-and-kivas-in-chaco-canyon-new-mexico/>.



agriculture, as the Anasazi homes were more permanent and better suited to the agrarian lifestyle.

The last example of ancient planning is from Pompeii. Pompeii is an important example because of its use and handling of the courtyard typology, something that has also been used in the southwest and Mexican civilizations. The Pompeii courtyard house creates a unique scenario where the homes are densely packed along a street as shown in Figure 3.7, and yet the home owner still has a very private outdoor space as shown in Figure 3.8.<sup>15</sup>

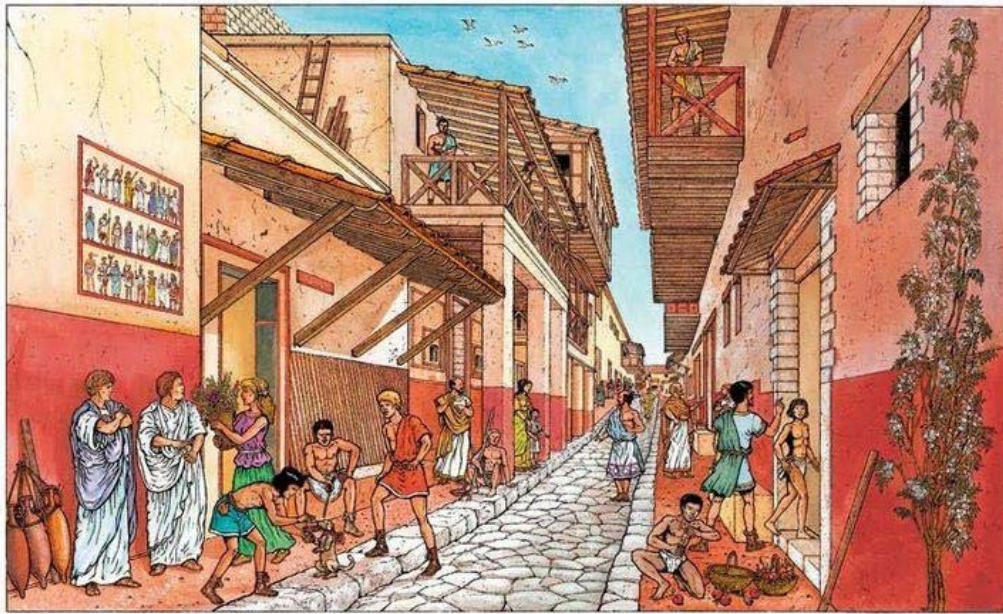


Figure 3.7. Dense, public street of Pompeii. (Choco)

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<sup>15</sup> Choco, MnM's. "Roman atrium house plan - Google Search." Pinterest. 2015. Accessed December 7, 2016. <https://www.pinterest.com/pin/510103095273819373/>.



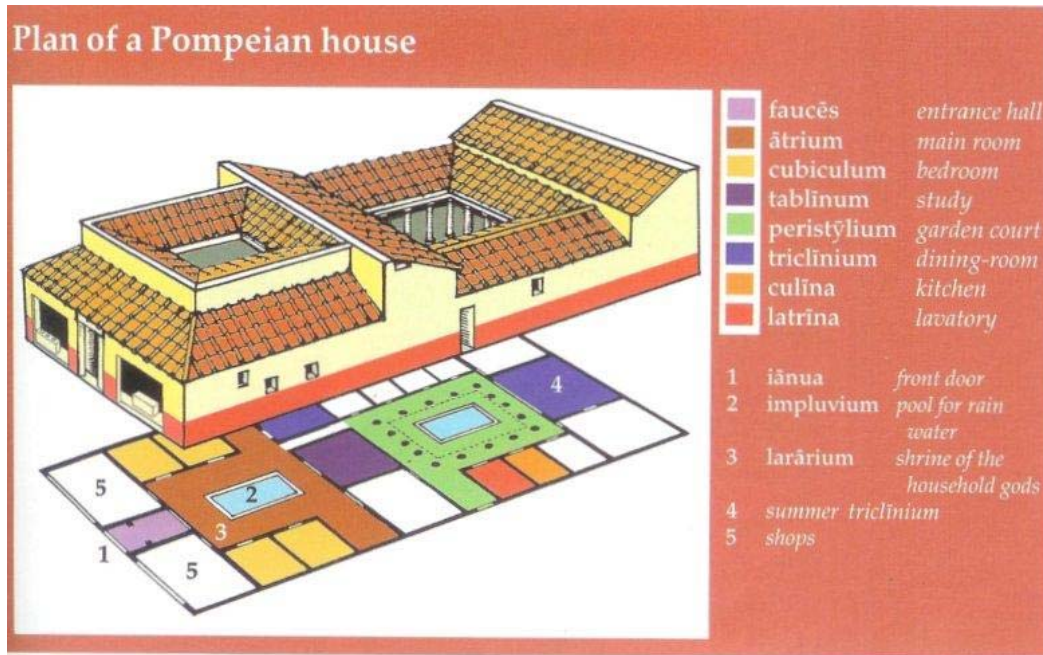


Figure 3.8. Courtyard homes that provide private outdoor space. (Choco)

The strategy of the house is a progression from public to more private spaces. The street being very public. The first rooms of the house that face the public contain shops, some even are claimed to be the first examples in history of takeout ordering. The next zone contains the chimney and rainwater collection. The slops of the roof direct water inside the house for use in the nearby kitchen area. This zone is semi private in the sense that it is like a living room or gathering space. The courtyard is surrounded by very private rooms, implying the courtyard was actually a special moment in the house to be isolated from the public life. Despite having neighbors to the left and right, there is still a private zone of relaxation and nature. The roof design funnels water towards the plants in the center. Interestingly, the dining room is the further room from the street, but it has a direct view into the courtyard. Many of the ideas used in the ancient's

courtyard schemes have direct relevance to the strategies of aggregating courtyard style homes in a masterplan and street setting.

### Modernist Prefabrication and Catalog Concepts

After industrialization began practices such as mass production, assembly lines, and replaceable parts, planners looked to see if some of those ideas could be applied to the housing market. The opportunity came after the housing boom in the form of the suburbs. After the two world wars, introduction of the car, and implementation of the highway systems, families began to desire homes away from the city.<sup>16</sup>

Levittowns, massive communities built very quickly, arose during this unique time period, where the primary of planners to was mass produce homes in order to save money. Costs were lowered due to the standardization of materials. All the homes were built in very similar fashions, with very fast method, as shown in Figure 3.9.

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<sup>16</sup> Galyean, Crystal. "Levittown - US History Scene." US History Scene. 2016. Accessed December 4, 2016. <http://ushistoryscene.com/article/levittown/>.

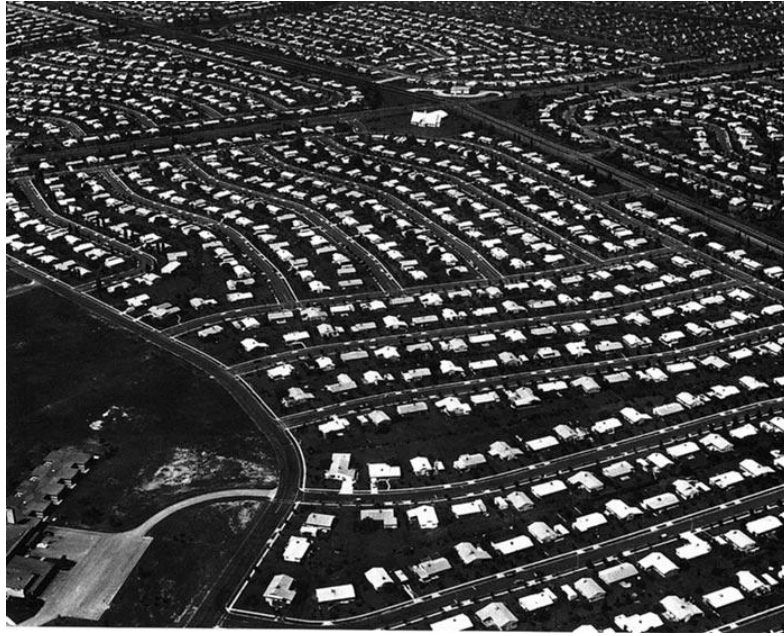


Figure 3.9. Levittowns created suburbs with extremely fast and cheap methods.

(Gaylean)

Important to note however, is that there was choice for the consumer. Although there weren't that many options, there were designs specifically tailored to certain family sizes and income levels. Prefabrication methods combined with a printed catalog of home styles gave the client a sense of ownership over the home, even though the neighbor might have picked the exact same size and style. These options are displayed in Figure 3.10.



Figure 3.10. The different sizes and style for home buyers in Levittowns.

(Gaylean)

In a sense, this might be the precedent most closely related to the goals of this thesis. There are many flaws in Levittowns however, including their dependency on the car to get food and shop. The customizability only goes as far as income level, so the towns begin to look very uniform and boring, almost a false sense of individuality.

One precedent during the modernist time period that perhaps tackled the issue of prefabrication and customizable options better was the Sears Catalog Homes. Much of the idea revolving around the catalog was about branding styles and themes, and lacked true customizability of program and functions. The homes could have similar shapes sometimes, but have a very American, or exotic style, like in the case of the Colonial versus Chicago Manor themed homes in Figure

3.11. Sears came up with 370 different versions, and built 70,000 homes between 1908 and 1940.<sup>17</sup>

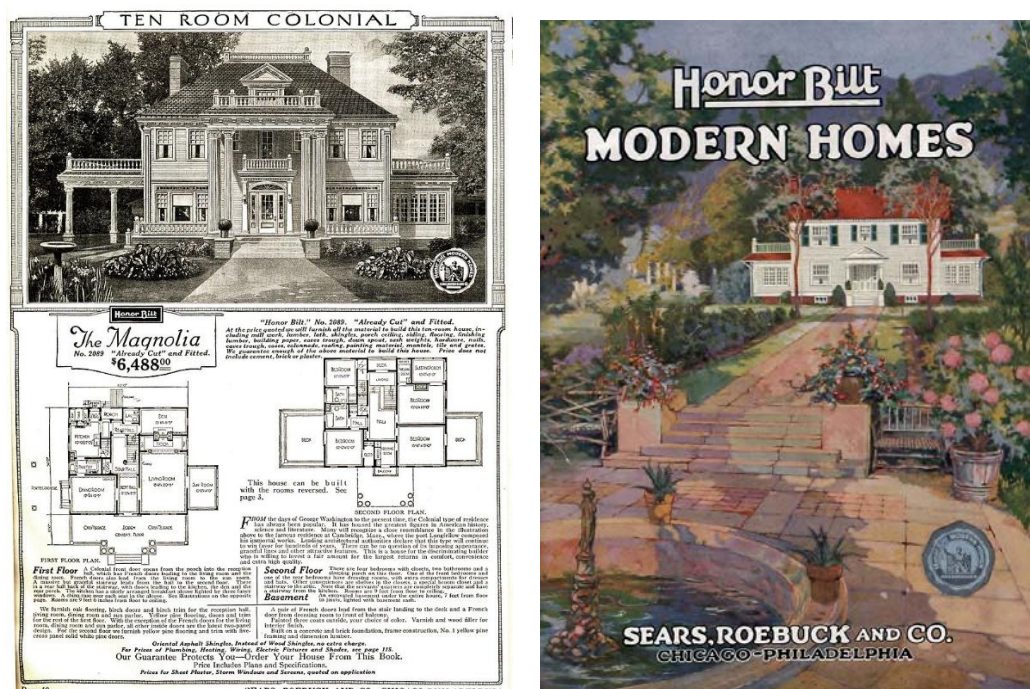


Figure 3.11. Sears Catalog Homes displaying different styled themes for similar shaped homes. (Sears Archive)

### Contemporary Sustainable Communities

There are several different ways of looking at contemporary sustainable communities. Some are more rural, while some are urban, but most tend to have unifying themes of conserving water, using renewable resources, using local materials, building public transit, incorporating mixed use buildings, and general walkability. Some of the more rural schemes may focus more on living off the grid, self-reliance, net zero living, and durability. Since this thesis is about

<sup>17</sup> Sears Archive. "Sears Homes 1908-1914." Sears Homes 1908-1914. Accessed December 4, 2016. <http://www.searsarchives.com/homes/1908-1914.htm>.

sustainable communities it will not look at the extreme rural scenario where someone is living alone in the wilderness via self-sustaining practices. It will also not look at the purely urban metropolitan style living, where sustainability is achieved more through living in efficient apartments units and other general benefits of density. There is a range in between that is appropriate for Bylas, a very open reservation land in the desert, with a highway and railroad nearby.

The first sustainable community to look at then is a very suburban style situation similar to Levittown. In this case at Prairie Crossing however, they have done a very good job of preserving open land and water, as opposed to building over everything as shown in Figure 3.12.<sup>18</sup>

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<sup>18</sup> Prairie Crossing. "A conservation community in Grayslake, Illinois." Welcome to Prairie Crossing. Accessed December 1, 2016. <http://prairiecrossing.com/>.





Figure 3.12. Conservation area and water features within view of homes. (Prairie Crossing)

These preserved wilderness areas provide habits for animals, create a more biophilia for humans to enjoy, and help reduce rapid runoff during storms. The plan view in Figure 3.13 shows how the homes are centralized around the wilderness areas as well as the main water body. All too often, suburbs just use grass lawns, but this community has much more functional greenery. There is also a commuter rail despite this being a more suburban setting.



Figure 3.13. Plan view of Prairie Crossings conservation strategy. (Prairie Crossing)

The next precedent is a step up in density. Mueller Village is a transit oriented sustainable community in Austin, Texas. It has a balance of standalone homes, row homes, and even mix use in the town center as shown in Figure 3.14.<sup>19</sup> Tying it all together is the use of a transit system to reduce the need for cars.

<sup>19</sup> Mueller. "Mueller. A mixed-use urban village in Austin, Texas." Mueller. A mixed-use urban village in Austin, Texas. Accessed December 6, 2016. <http://www.muelleraustinonline.com/>.





Figure 3.14. Different housing densities all in one village plan. (Mueller)

The masterplan in Figure 3.15 shows how the community is divided into different zones of density.



Figure 3.15. The varying zones of density and function. (Mueller)

The densest areas tend to at nodes along the main transportation route. One last notable feature of the masterplan is the use of central garden courts as opposed to alleyways, as shown in Figure 3.16

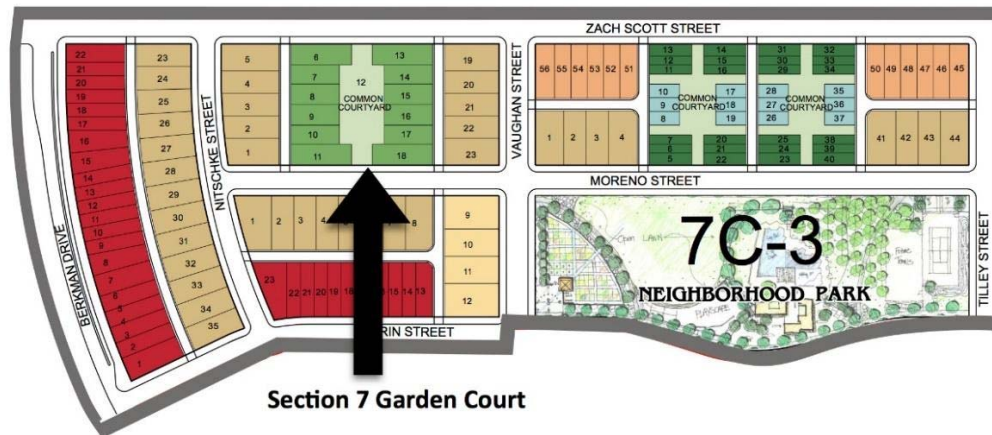


Figure 3.17. Garden court where community events can be held in the park.

(Mueller)

The shared garden court is a great idea for promoting the benefits of having some functions be shared like park space. Again, instead of just grass, more functional greenery is used. Figure 3.17 gives a better sense of what it is like in the garden court.



Figure 3.17. Garden court in Mueller village. (Mueller)

Mueller Village is a case of simply being an extremely well designed community, but it doesn't necessarily employ more technological based sustainable practices like in the next precedent.

zHome is only a small Urban Village in Issaquah, Highlands, but it is a good example of increasing the density even further. In this case, the design does employ the newest technology and strategies of sustainability through its use of solar panels, as shown in Figure 3.18<sup>20</sup>

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<sup>20</sup> Living Future Institute. "ZHome." Living-future.org. Accessed December 10, 2016. <https://living-future.org/reveal/zhome/>.





Figure 3.18. A more technological approach to sustainable communities. (Living Future Institute)

Despite being much taller than the houses at Mueller Village, zHome applies a similar strategy of creating a small court in the center of the houses. Even the entrance to the court has small solar panels. The Panels are spaced far enough apart that they will not shade each other, an important task when designing solar communities. Other notable features of zHome is that it is a living certified community based on the criteria of the Living Building Challenge. It is climate neutral, and most importantly when dealing with solar, a net zero energy community. This means that it actually produces slightly more energy than it consumes in order to guarantee net zero.

Another living certified community that actually achieved every pedal of the Living Building Challenge is architect Mike Binder's team's entry for the DC Affordable Living Design Competition. An extremely difficult challenge is to

design something that is both affordable and net zero energy and water etc. One of the ways it concluded was the most efficient way to do this was to actually have shared land in the community designated for things such as gardens, composting, and water filtration, as shown in Figure 3.19.<sup>21</sup> The Name of the project was Urban Grapevine, due to the food that able to be grown within the community. Its method of water filtration shown in Figure 3.20 was reverse osmosis, but since this system can be expensive, it was made more efficient having the homes pump their grey water to a shared cleansing station shown in Figure 3.21. The homes are affordable in the sense that many of the features are seen as expensive down payments upfront, but with huge benefits in the long run. They are essentially investments that pay off later like in the case of solar panels or expensive composting, gardening and water filtration that then saves food and water I in long run.

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<sup>21</sup> Binder, Mike. "Designing a Better Future." Reality-alt.com. June 8, 2015. Accessed December 1, 2016. <http://reality-alt.com/blog/archives/442>.



Figure 3.19. Poster displaying the homes and their shared community spaces.

(Binder)

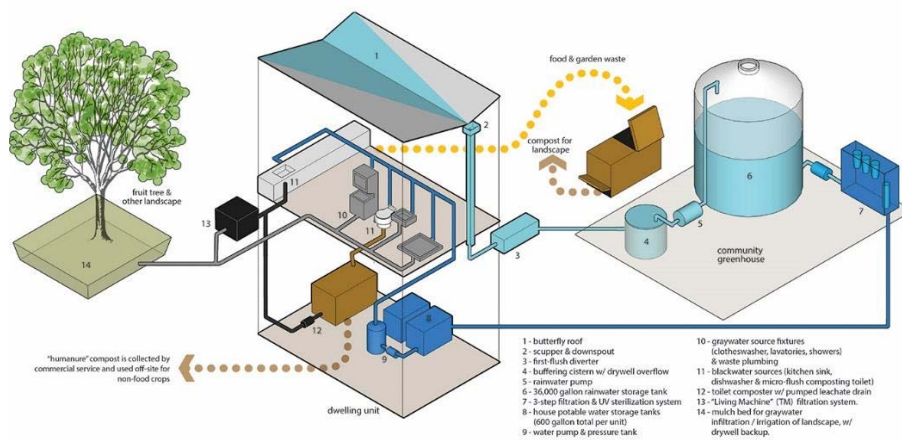


Figure 3.20. The water filtration and compost strategy. (Binder)



Figure 3.21. The shared cleaning stations within the community. (Binder)

The completion entry is a rare example of a project that has achieved every pedal.

The final precedent has not achieved the technological feats, but it is an example that is most similar to the situation in Bylas, where water is limited.

The Tapestry Development is a desert Community in the Mojave river basin in California. It employs the idea of zoning, but makes it more special and interesting by applying unique names to each area of the master plan, as shown in Figure 3.22.<sup>22</sup> One theme it shares with the first precedent, Prairie Crossing, is that it preserves some of the open land features as shown in Figure 3.23. The masterplan carefully centralizes the three villages around the river basin, the crucial source of water in the community as shown in Figure 3.24. Tapestry

<sup>22</sup> Hesperia. "Hesperia's Tapestry Master-Planned Community will be a Jewel of the High Desert." The High Desert Report. April 17, 2015. Accessed December 2, 2016. <http://www.thehighdesertbradcoreport.com/articles/2015/04/hesperias-tapestry-master-planned-community-will-be-a-jewel-of-the-high-desert/>.



Development made water conservation the core of the design. Each zone has its own town center, where walkability is promoted.

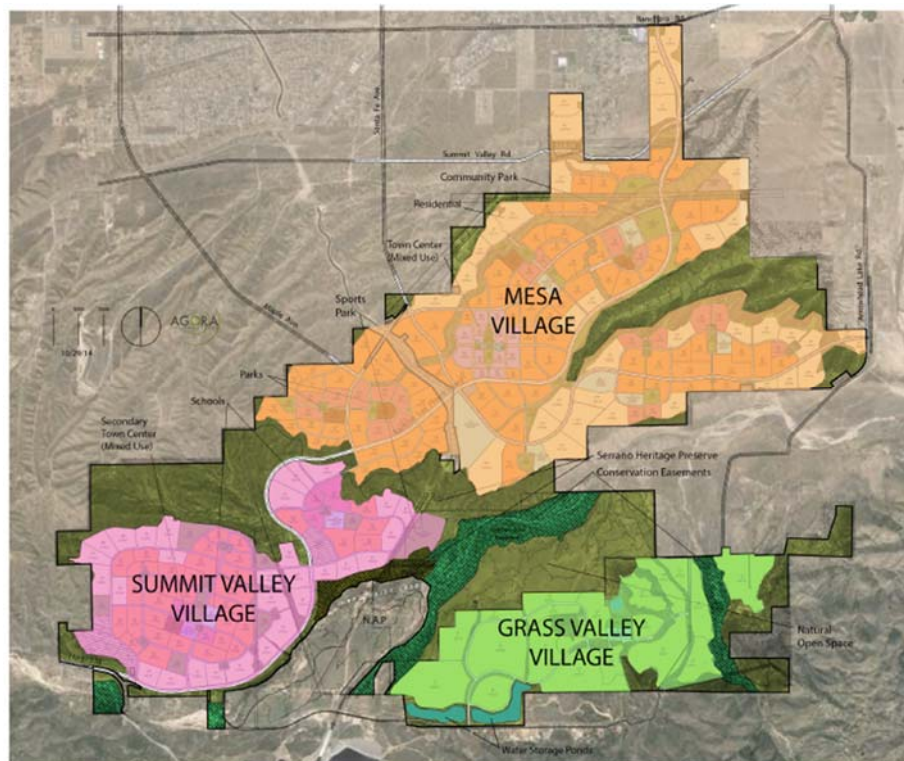


Figure 3.22. The names of the various zones within Tapestry Development.

(Cashion)





Figure 3.23 Preserving open land, and promoting walkability (Cashion



Figure 3.24. Conserving and protecting water features and promoting views of nature.

Similar to Bylas, there is a river and a mountain serving as the two most prominent natural land features. Receiving very little rainfall is another common pressure. The river has to be carefully protected from various sources of pollution. Rain collection becomes even more crucial in the desert. Many of these themes come up again in the design portion of the thesis, but before that, a full site analysis of the Apache tribe in Bylas, Arizona is in due order.

#### **Chapter 4: Site**

The Bylas community in Arizona is part of a larger story of the Apache. Before analyzing and diagraming the site itself, the larger context must be painted.

##### **History and Culture of the Apache**

The site being analyzed is Bylas, Arizona, a town part of the San Carlos Apache Reservation. However, in order to understand how things go the way they are today, the history and origins of the Apache people must be summarized.

The Apache have traditionally lived in the semi-arid desert region of the modern-day American Southwest. The tribe's homeland is centralized around New Mexico, with areas reaching into Colorado, Oklahoma, Texas, Mexico, and Arizona as shown in Figure 4.1<sup>23</sup>

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<sup>23</sup> Burns, David. "Impact on Indians: Reservations and Conflicts." Fasttracking.com. 2009. Accessed November 04, 2016. [http://www.fasttrackteaching.com/ffap/Unit\\_2\\_Westward/U2\\_Impact\\_on\\_Indians.html](http://www.fasttrackteaching.com/ffap/Unit_2_Westward/U2_Impact_on_Indians.html).



Figure 4.1. Homeland of the Apache (David Burns)

The nomadic tribe spread from Texas in recent times, but tracing the migration of the ancestors of the Apache is made much more difficult due to the lack of written records. Archaeology and oral tradition, and linguistics provide evidence that the Apache, like many Native American tribes, most likely migrated from the North via the frozen Bering Strait during the most recent ice age 12,000 years ago, as shown in Figure 4.2. What is important to note is that the Apache and their language places them in the larger ancestral family of the Athabaskans or the “Na-Dené” and “Dené”<sup>24</sup>, who were part the 3<sup>rd</sup> and final wave of migration over through Alaska. It is important to realize they were part of the last wave, because along the way southward, they encountered and proceeded to adopt

<sup>24</sup> Stromberg, Joseph. "Ancient Migration Patterns to North American Are Hidden in Languages Spoken Today." Smithsonian Magazine. March 14, 2014. Accessed November 02, 2016. <http://www.smithsonianmag.com/science-nature/ancient-migration-patterns-north-america-are-hidden-languages-spoken-today-180950053/>.

traditions from other older civilizations such as the Anasazi Pueblo Indians and Plains Indians. Due to theories of how some groups stayed north, while others continued south, the Athabaskans are divided into three groups, the Northern Athabaskan, Pacific Coast, Athabaskan, and Southern Athabaskan which includes the Apache (Figure 4.2).

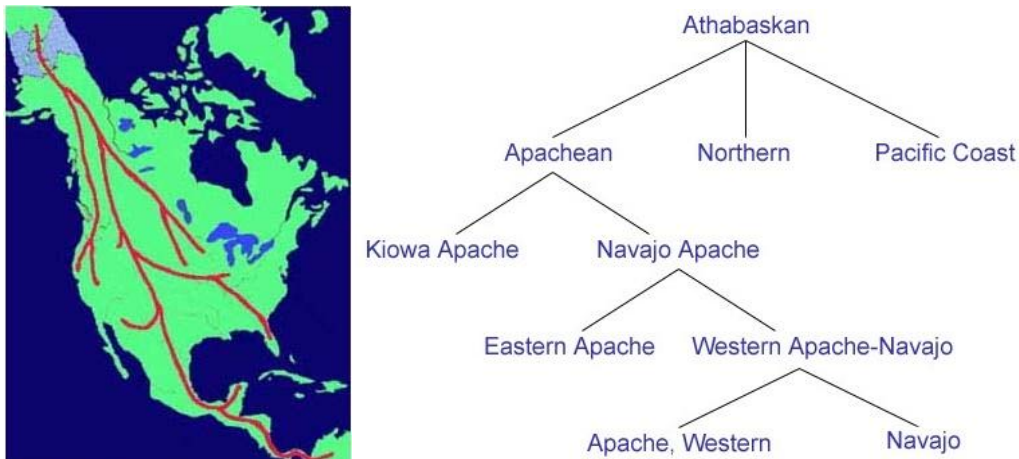


Figure 4.2. The likely migration paths of the Athabaskans and descendents (E-Meld: Douglas)

The theory of what drove migration revolves around the environmental context of the Northern Subarctic terrain. It is believed that for a while the Northern Athabaskans's primary source of food was the caribou and salmon. However, the tendency of the game to travel encouraged the people to adapt to be more mobile and flexible, never settling in one place for too long, and always searching for space seasonal and scattered resources<sup>25</sup>. The culture relied on a

<sup>25</sup> Huscher, Betty H., and Harold A. Huscher. "Athapaskan Migration via the Intermontane Region." *American Antiquity* 8, no. 1 (1942): 80-88.

small-group and individual strength mentality for survival, as opposed to large agricultural based communities. This meant it was common for group to split in different direction, and migrate towards richer sources of food. This is what likely happened when one population diverged and spread throughout Cordillera, and subarctic conifer forest that had similar ecological context to their homeland<sup>25</sup>. In fact, for the most part, this south eastern migration path is highly probable because the Rocky Mountains would have provided a significant barrier from moving any further westward after initially diverging in Alaska. What is more unclear, is how the Apachean Athapaskans eventually got to the Southwest. One theory is that from Canada, they actually migrated from the northwest, but came down through the central Plains. The one bit of evidence the backs this is the fact that one of the Apache groups show distinct cultural influence from the Plains tribes, meaning that the Quecheros, the Teyas, and the Vaqueros that the Spanish encountered, may have actually been Apache<sup>25</sup>. However, there is still only one group that has this Plains influence, and it is unclear exactly when they adopted the Plains traditions. The more accepted theory is that the Apachean Athapaskans simply continued along the Rockies which resembled their homelands northern terrain. From West-Central Canada they would have taken route through Colorado or Utah in order to reach the Southwest<sup>25</sup>. The reason this theory is more widely accepted is because it actually has some archaeological proof to back it as documented by Huscher. Along the route, “from sites ranging from the Plains

across New Mexico and Arizona as far as California,” are “circular or sub-rectangular stone structures, often with dry-laid masonry walls and characteristically built in prominent locations” with east facing doors. This strongly resembles the Athapaskan’s more ceremonial “Hogan” style structures<sup>26</sup>. Also, in the same areas are remains of pointed bottom pottery in the style of the Navajo who are also descendents of the Athapaskan and very closely related to the Apache of the Southwest. The Apache and Navajo languages are similar enough that they can understand one another, meaning this particular piece of evidence strongly related to the Apache’s own migration history.

Once the Apache reached the Southwest between 1400 CE and 1525 CE, they continued their traditions of traveling with game, this time however, it was Buffalo as opposed to Caribou. Their nomadic style travels inevitably led them towards encounters with others, like their Navajo cousins, Anasazi Pueblo Indians, Native Mexicans, and the Spanish. What makes this time period difficult to analyze is that the Spanish erroneously called all the tribes they met “Apache” confusing what little written documentation there is. The Apache identity was only later distinguished from other Natives. What is known throughout archaeology, oral tradition, and linguistics, is that the Apache at some point after

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<sup>26</sup> Seymour, D. J. (2009). Nineteenth-century apache wickiups: Historically documented models for archaeological signatures of the dwellings of mobile people. *Antiquity*, 83(319), 157-164. Retrieved from <http://search.proquest.com/docview/217557831?accountid=14696>

being in contact with other cultures, shifted from nomadic hunting and gathering, to that of hunting and farming.<sup>25</sup> This is one of the first key examples of the Apache's willingness to adopt the practices of other cultures in order to secure an advantage. The adaptability was crucial to their survival because they were no longer completely dependent on game as a food source. That is why their homeland never shifted significantly after reaching the southwest, because more often they were able to stay in one place and survive. They also adopted the more permanent architectural techniques of the Anasazi pueblo villages with their adobe house technology that had been developed over many years as a very successful climatic solution to the hot and arid region. The Apache also adopted the Anasazi's temporary home designs as well which used localized materials to make brush structures or tipis. The Apache's flexible wikiup was already quite similar to this (Figure 4.3), so they continued to use a mix of both throughout the years<sup>26</sup>. Not all contact with other Natives was peaceful. Apache had long been trained to move quickly and taught various hunting techniques, and so they were willing to fight other tribes when the situation demanded, and they were quite successful at it.





Figure 4.3 Traditional flexible, temporary Wikiup of the Apache (what-when-how.com)

The Apache split various ways and formed their own unique tribes with differing elements. Some of these tribes came into contact with the Spanish who brought another significant technology soon to be adopted: the horse<sup>4</sup>. It seemed it was almost the perfect animal for the traditionally mobile warrior tribe.

U.S. Settlers arrived in larger numbers in the Southwest around 1846 when the U.S. went to war against Mexico. At this point, the Apache saw the U.S. as a tolerable ally since they were taking care of their enemy, the Mexicans. The Mexicans, despite their disputes with the Apache often did settle things with official treaties. When the war ended, and the gold rush began, the Apache had to now deal with United States, a foe that they soon realized was much more



powerful than the Mexican army. In 1875, after many American settlers complains, the U.S. military began the forced removal of the Apache. One the tactics they used to control the Apache's source of economy and food was to promote the slaughter of the Buffalo, as displayed in Figure 4.4.

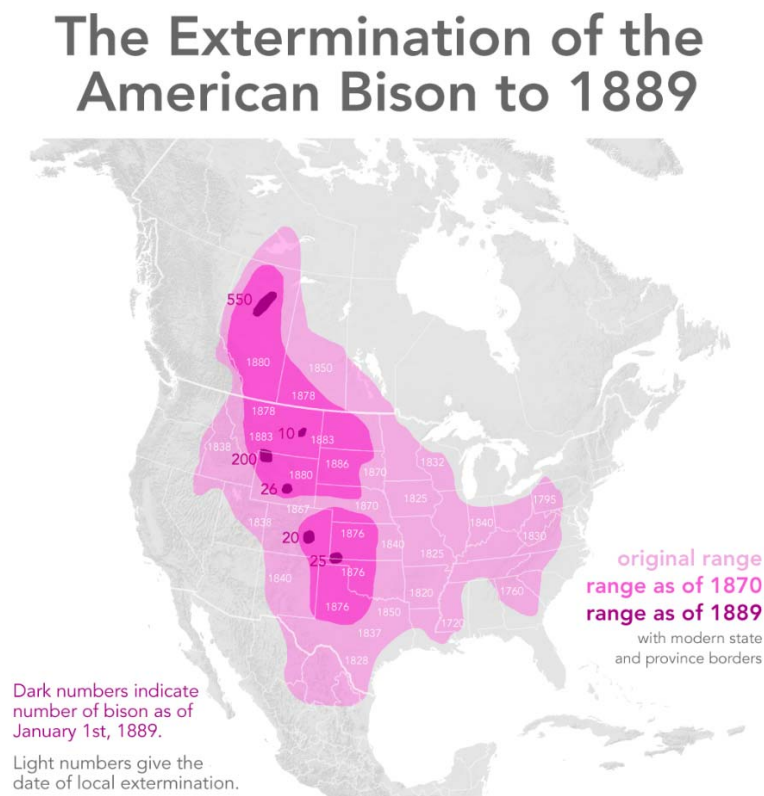


Figure 4.4 Slaughter of the Bison, the Apache's source of food.

Geronimo famously resisted capture, and became a nuisance to the army for a very long time. The U.S. afraid of further aggression, placed some of the Apache warriors in a reservation in Oklahoma near Ft. Sill so that the military could keep a close watch on them.<sup>27</sup> Others, especially children, were forced to assimilate in

<sup>27</sup> History.com Staff. "Geronimo." History.com. 2009. Accessed December 2, 2016. <http://www.history.com/topics/native-american-history/geronimo>.

the American population. The remaining were placed on reservations in San Carlos and other areas in Arizona. Eventually they too became Americanized, but willingly so. Many parts of the culture persist today however, like the girl's rite of passage ceremony, and various religious rituals and musical traditions.

### Climate of Bylas Arizona

The southwest area is considered a semi-arid desert, receiving approximately 11 inches of rain per year. Phoenix, 2 hours away from Bylas, the area of study, shows that the monthly precipitation varies heavily, where the period from the end of Spring leading into June receives almost no rain at all as shown in Figure 4.5<sup>28</sup>

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<sup>28</sup> US Climate Data. "Climate Arizona - Phoenix." UsClimatedata.com. Accessed November 05, 2016. <http://www.usclimatedata.com/climate/arizona/united-states/3172>.

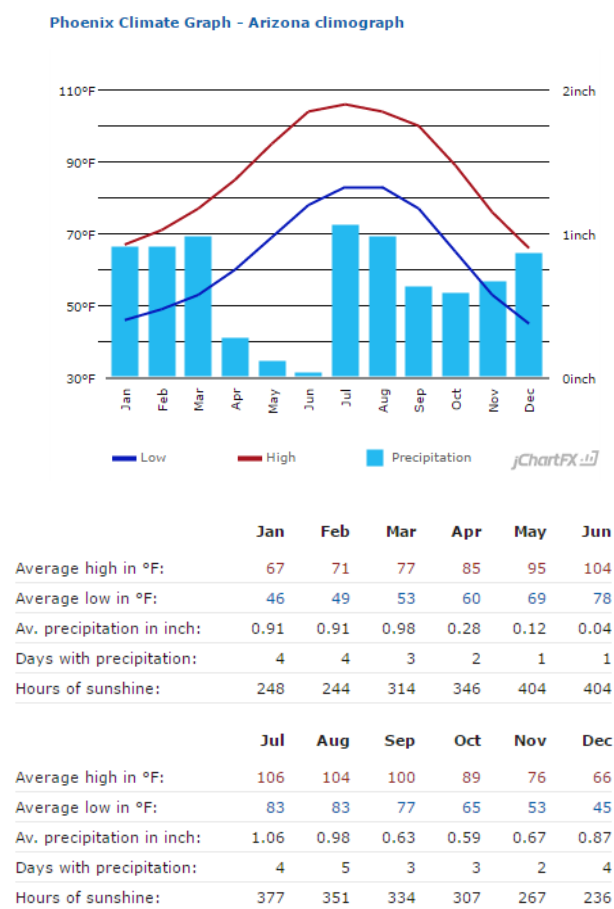


Figure 4.5 Precipitation as well as high and low temperatures for Phoenix, Az.

(us-climate data)

### Bylas Site Analysis

Although there are many Apache sites within the reservation that are in need of housing, the community in Bylas, Arizona has specifically shown interest in the University of Maryland's solar home entry for the Department of Energy's Solar Decathlon. Bylas has already undergone at least one masterplan in anticipation of future growth as shown later in Figure 1.4. They are no doubt aware of the current events surrounding the Dakota Access Pipeline and its threat to the Sioux Tribe's sacred land and water supply. The Apache have reached out

to UMD because they have expressed that they wish to live more sustainably, where nonrenewable resources like oil would become eventually obsolete and be replaced by the energy that comes directly from the sun in the form of PV panels. Given state of unemployment and low wages in this area, there is a unique chance, in an ideal world, to increase the quality of living, revitalize the economy, and increase energy independence and self-reliance, but at the very least, create affordable, replicable, and sustainable housing for the citizens of Bylas, Arizona. Depending on how the project is handled, the Bylas community could end up being an outstanding model of sustainable living, but the process would be slow, as right now the town is heavily Americanized, with a dependence on the car and oil much like in the Suburbs. While they want to live more sustainability, they also simultaneously wish to bring back more elements of their own culture to the community. In many ways their culture utilizing every part of the animal, never wasting anything, adapting when needed, and flexible living styles is already in sync with sustainability. Therefore, with small progressive phases, the town could eventually begin to function in more sustainable, flexible, adaptive, regenerative, and harmonious ways as envisioned by both the traditional Apache way of life and the mission of the Living Building Challenge.



Bylas, Arizona is a small community along route-70 that is part of the larger jurisdiction of the San Carlos Apache Indian Reservation within Graham County, Arizona. It is named after Bailish who was a chieftain of the Eastern White Mountain Apache. According to city-data's extrapolation from the U.S. 2010 census, the population is 1,962 and growing. It is 43.1 percent male, and 56.9 percent female. The median age is 29.3 years, younger than the rest of Arizona at 36.8 years. The median income is \$43,802, lower than Arizona's \$48,510. Meanwhile, unemployment is at 7.7% which is slightly higher than Arizona's 6.4 percent as well as the country's national 4.9% rate<sup>29</sup>. Most jobs in Bylas are derived from agriculture, commerce, and the casino 40 minutes away. Bylas itself does not receive much tourism, as the main Apache attractions are at Apache Junction much further west closer to Phoenix. Additionally, the San Carlos reservation's main community is actually situated further northwest from Bylas, in the denser town of San Carlos. About a 30-minute drive away, the town is the seat of government for the San Carlos Apache Indian Reservation and has been around longer and therefore has a more established infrastructure of schools, post offices, churches, police, roads. However, even with more touristic backing, San Carlos suffered from large unemployment and low wages in the year 2000, with 58.8% of the population living under the poverty level at a median household

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<sup>29</sup> City-data. "Bylas, Arizona." City-data.com. 2010. Accessed November 04, 2016. <http://www.city-data.com/city/Bylas-Arizona.html>.



income of \$13,412. Today it is not much better with the median household income at \$23, 959 and per capita income at \$8,298. Half of the households are families, with old and young living together. This trend of inter-generational families is a tradition common to not only the Apache, but many Native American tribes. This is why it is important to keep their situation in the context, because although they are happy to live as a larger, extended family, these are statistics that are often labeled by government standards, as “overcrowded” and “impoverished” while the people go on living unaware of these labels. There are many real issues that the tribe faces, but intergeneration family style living and expandability is an opportunity, not a problem.

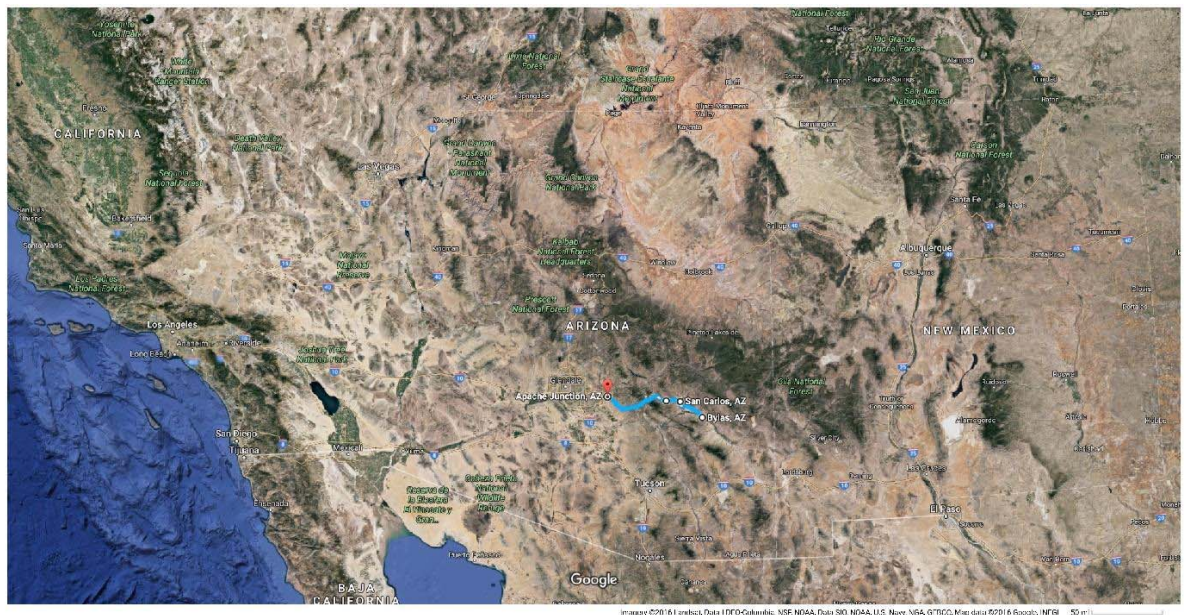


Figure 4.7 Bylas and other Apache destinations within larger context of the Southwest. (Google)

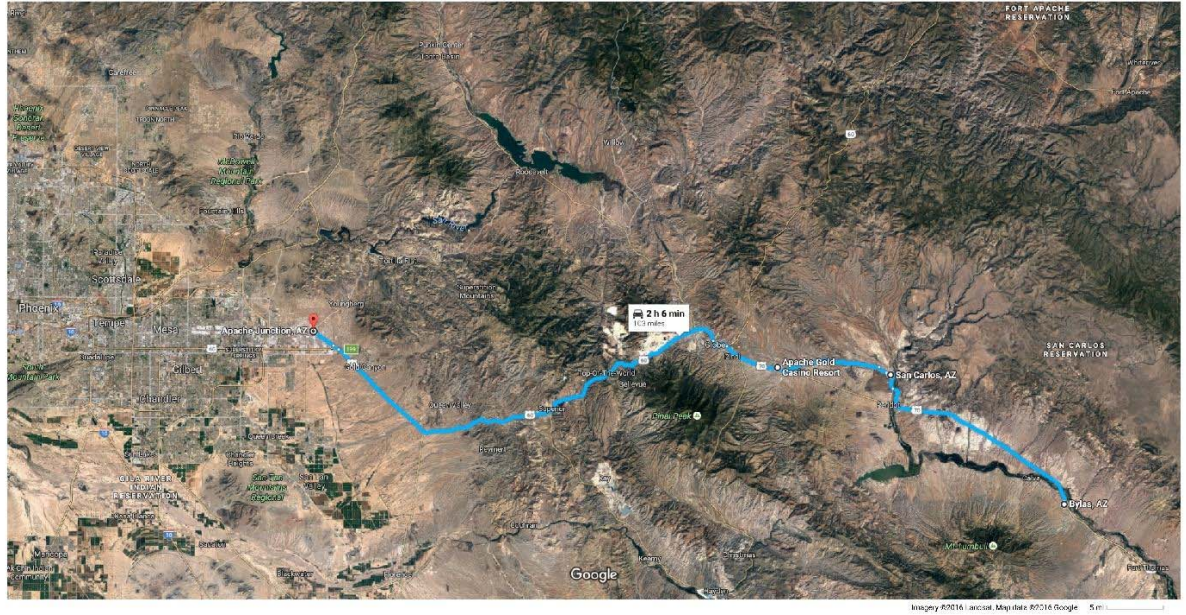


Figure 4.8. Most of the locations important to the Apache are West or North of Bylas. (Google)

One feature that distinguishes Bylas from any other Apache community is its proximity to Mount Turnbull, a sacred site to the apache and the highest point in the Santa Teresa Mountains with an elevation of 8,282 ft.<sup>30</sup> As shown in Figure 4.9. It dominates the landscape near route 70, but currently requires permits for campers and visitors.

<sup>30</sup> "Mount Trumbull." Summitpost.org. Accessed November 04, 2016. <http://www.summitpost.org/mount-trumbull/154115>.





Figure 4.9 Mount Turnbull and the local desert shrubbery (Summit Post)

The other dominant feature is the water source of the Apache, the Gila River to the east.

#### Apache Today

Direct interviews provide a better understanding of the current lifestyle and aspirations of the Apache. The southeastern Arizona Arts in Academics and Mt. Turnbull Academy conducted a storytelling workshop of the Apache people, both young and old. The people of course have a wide range of viewpoints on their current situation. A young woman talked about how she regretted not having a traditional Sunrise Dance. “Now I wish I would have had one because I’ll never have a chance to experience that. I would like to learn more about my culture and traditions... If young people got an education then there would be more hope .... If I come back, I hope that the reservation is cleaner, with no more alcohol and

drugs”<sup>31</sup>. Not all express an interest to come back, as accounted by a young man. “I want to move out of Bylas, get far away from Arizona... I want to make my own money and give my mom money to spend. I want to go to college, get a trade ... so you get paid good and you know what you’re doing”<sup>31</sup>. An older gentleman talks about bringing back the Apache culture, and teaching it to others is more important to him than formal education:

“They call the violin ‘wood that sings.’ This is what they call a lost art. You don’t see it anywhere else anymore. So I revive it. I do workshops all over [showing] piece by piece how to make them. In the workshops I tell them about my life story. I tell them I was lucky. I never did go to school. But now you need school. You have to have a paper that says you went to school, otherwise you’re nothing.”<sup>31</sup>

A middle aged man expresses his concern with some of the Americanized trends. “It [used to be] a lot different than today, you believe me. We had no running water. We had no electricity. We didn’t have much of anything –TV or radio....To me, I miss those days compared to today. Food was good. We ate a lot of wild plants. Especially acorns, yuccas, the roasted kind ... century plants”<sup>31</sup>. An older woman talks about the strong bond the Apache share, where she is hopeful the people leaving to get degrees will come back. She mentions the words of her grandfather who said “your bows and arrows are now your degrees and knowledge and education, that’s how we have to maintain the Rez and our

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<sup>31</sup> Schachter, Josh. "Southeastern Arizona Arts in Academics Residencies." Joshphotos.com. October 2009. Accessed November 3, 2016.

tribe”<sup>31</sup>. An accomplished woman expresses her belief that people can work hard to accomplish their dreams:

“I worked my way up the ladder, behind the scenes, and eventually I was able to work my first job as a TV news reporter in Tucson ... I ended up staying with that for 20 years. Everybody who has a desire to accomplish something can do it. I came from similar backgrounds as many people here on the reservation. I grew up in a two-room house with no plumbing, no electricity, and we lived with my grandparents. As a child, I lived in poverty but I didn’t feel poor because of the love that surrounded me. I think when you have a lot of love, you feel wealthy. So, I feel very blessed”<sup>31</sup>.

While there is a vast degree of differences in opinions, most express a willingness to want to learn or in some cases revive parts of the Apache culture. Most that decide to move out, have plans of returning with new aspirations to help improve the community in various ways. This variance and diversity of backgrounds is something that is expected to play into the user interface and customization options of the home. It is perhaps useful then that many of the people are tech savvy and regularly use things like Facebook and apps, because the end goal of the thesis is for all the of home’s client-based user interface customization and smart home adaptability features would all be incorporated in an application that could be accessed from one’s smartphone.

## **Chapter 5: Design**

The overarching goal of the house is that it can be reconfigured in many different ways depending on the user's preferences, but the DNA, core or essence of the houses functions would drive the crucial performances and stay largely the same as they are more based on climatic influences. In theory, Bylas is just one community, in one specific climate region with a unique historical background that would be inputted into the design. The house however, contains so many options, that it can act a solution to a completely different climate because the materials, R-values, and systems could be inter-changeable base on the climate date input, while the look, feel, and program of the house could be changed based on user input through a versatile online app. This thesis will use the Bylas site as example of how even the most culturally rich and adaptive people can find the perfect design solution within the thousands of options available. While buildings that are in cities have very specific sites that imply too many variables for a mass-produced solution, houses have typically been designed in a cookie cutter style fashion since the landscape and climate is the same through vast stretches of land. This is especially true of planned communities. This is why when a need for more housing arises, if it can be done in a fast, efficient way that still produces a wide variety of options for every client, many more will be satisfied with their home, and the community can have a range of options that are still tied together in a more meaningful way, and yet don't become so diverse as to appear outlandish in comparison to the rest of the neighborhood. While the house design will largely be designed essentially by the user's choices, it is important that the overall

masterplan itself be designed to be extremely specific to the needs of the community, and can't be mass produced through any sort of method. WLB, the current firm working on the masterplan for Bylas, will act as a placeholder in this case, where the ReAct home design will be inserted. More specifically, as shown later, the hypothetical client choice of the compact home will be sited halfway between the river and mountain along an existing street. Before this specific option is chosen at the end, it is important to look at all the options that were not chosen, but considered. This way, it will be shown exactly how a client would be able to sort through the various options in an organized fashion.

### Default Types

Earlier in the thesis, the figures 2.2 through 2.6 showed how a user would sort through a generic version of the app and its variables. Now, the finished design will show the raw data that would have to be inserted into the apps database in order to have all the necessary images and pdfs to create amalgamations of every single possible combination of variables. The clearest way to demonstrate this is with the variable, shape. Shape is easy to understand because its sub variables include which direction to extend the house. This user will be able to bump out additional space to the front, back, left or right, and possibly in some cases even up in the z direction. Each homes shape would essentially have a property, or coordinate, that helps identify it and organize it in the app when making changes. In this case the coordinate does not have a z axis, so it just the first letter of each direction, F (front), B (back), R (right), and L (left). North, South, East and West is not used because the house could be any orientation, but front, back, right, and

left is true assuming one side is chosen to have the front door where the street is, no matter what orientation that street is. Figure 5.1 shows every possible combination for shape when the only options are to grow the house left or right. These options grow exponentially each time a variable is added. This is the case in Figure 5.2 for the compact scheme which adds the variable for front and back. Figure 5.3 shows how, the current pick is show in the center, in this case it's the baseline default,  $F(0)$ ,  $B(0)$ ,  $R(0)$ ,  $L(0)$ . However, if the user were to decide to slide right and grow the house in that direction, the software would know to add one incremental value to the  $R$  variable, producing the new central coordinate,  $F(0)$ ,  $B(0)$ ,  $R(1)$ ,  $L(0)$ , but also shifting every single visible option on the outskirts by  $+1 R$ . That way, like was shown earlier with the generic app in Figure 2.2, the center will always be a live updated model of what the house looks like, and the horizontal and vertical axes show the future possible options of what the house could look like after sliding left, right, up or down.

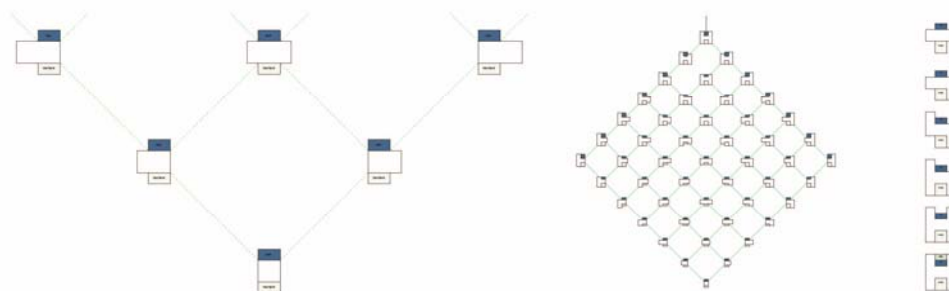


Figure 5.1 Decision trees for the variable shape in the Court scheme (Chris Courtney)

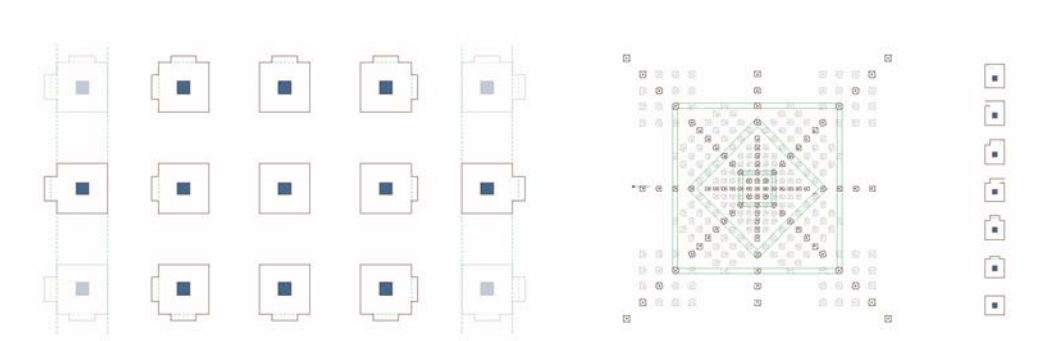


Figure 5.2 Decision trees for the variable shape in the Compact scheme (Chris Courtney)

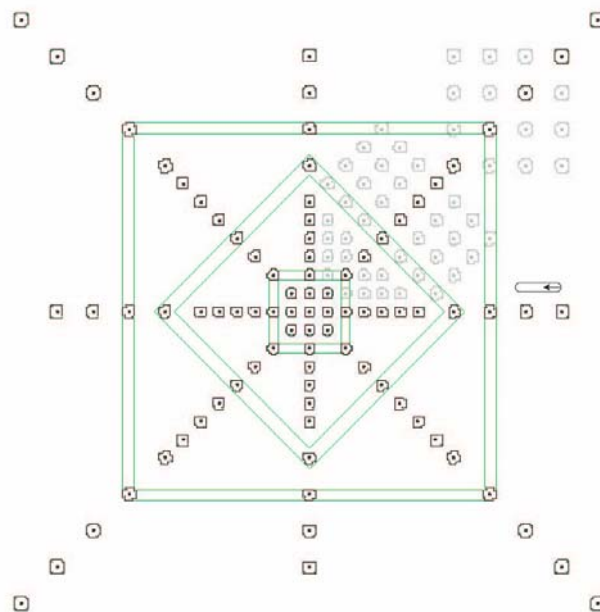


Figure 5.3 Decision tree with live updating center coordinate for front, back, left and right variables. (Chris Courtney)

Figure 5.3 the decision tree for the compact scheme, where the diagonal is the amalgamation of adding the choices of +R(right) and +B(back), or essentially the line  $R = B$  ( $y = x + 0$ ). It is interesting to note that if user wanted to have this amalgamation line to be the new horizontal axes upon which to view his or her choices, that would be possible, if for example the site only allowed growth to the back or right. This back/right line could then be sorted along a completely different variable such as material, to see in real time how growing the house back and right looks mapped across how changing the exterior wall material looks.

The idea of the default type, or initial baseline settings, in this case  $F(0)$  ,  $B(0)$  ,  $R(0)$  ,  $L(0)$  for the property, shape, is very important to this concept of customizable homes. The default type essentially becomes that baseline home, the simplest most essential home without anything added to any variable. This is useful because for a lot of people, using this app will seem like a hassle, or too confusing. Even if they choose to opt out of the app and survey method of narrowing their choices, they could still pick from a set of baseline default options that are useful starting points for their search for the perfect home. The architect would then work more closely with clients like this, so as to guide their decision making to its logical end without the app.

One of the quickest ways to grasp information, like with the main 15 default options, is a chart or matrix. This crucial matrix to the project is created by charting the housing type: cluster, compact, core, by use: single family, duplex, complex, and others. It is the organization of the default, or most essential base level homes of each type. It could even be thought of as the most consolidated, pure, starter



home, with no mixing of variables or hybrids. It's as if every property value for the three main archetypes is set to zero and no changes have occurred yet. Of course, depending on the climate zone, some initial material variables will be set if someone were to actually choose an unmodified default home as their pick, but the materials variables would be set to the ideal, most efficient, or "highly recommended" configuration of components for that particular climate zone. Figure 5.4 shows the matrix with the headlines going horizontal reading, DNA, single story, duplex, half levels, and complex. The vertical headlines read, court, cluster, compact.

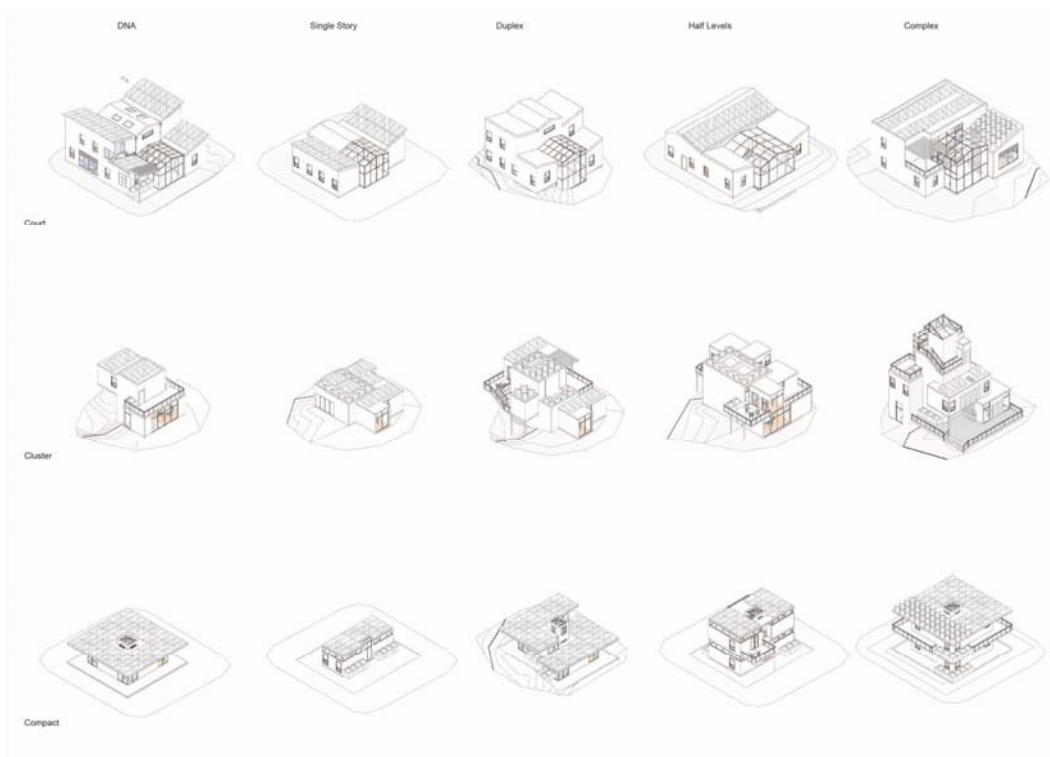


Figure 5.4 Master matrix of the 15 main default options. (Chris Courtney)

With this method all 15 default types are shown, one combination for each type and programmatic living style. The DNA option would itself be the 0,0 baseline coordinate of all variables. It is the fundamental beginning point of all the other options, and its essence is seen even in the most complex variations that spawn off of it.

If the analogy of the DNA is explored further, then the concept of the “core” would be the gene common to all types. It is contained within every option that branches off, like a family tree. Figure 5.5 shows the plan views of the default courtyard options where the DNA is shown in 3D with a focus on the vertically of the core and its corresponding spine wall.



Figure 5.5 Default options for the courtyard scheme with DNA baseline option central to all. (Chris Courtney)

Figure 5.6 shows the same concept but for the compact scheme, where the focus is on the centralized core that acts as the sources of all the systems in this transportable tiny home.

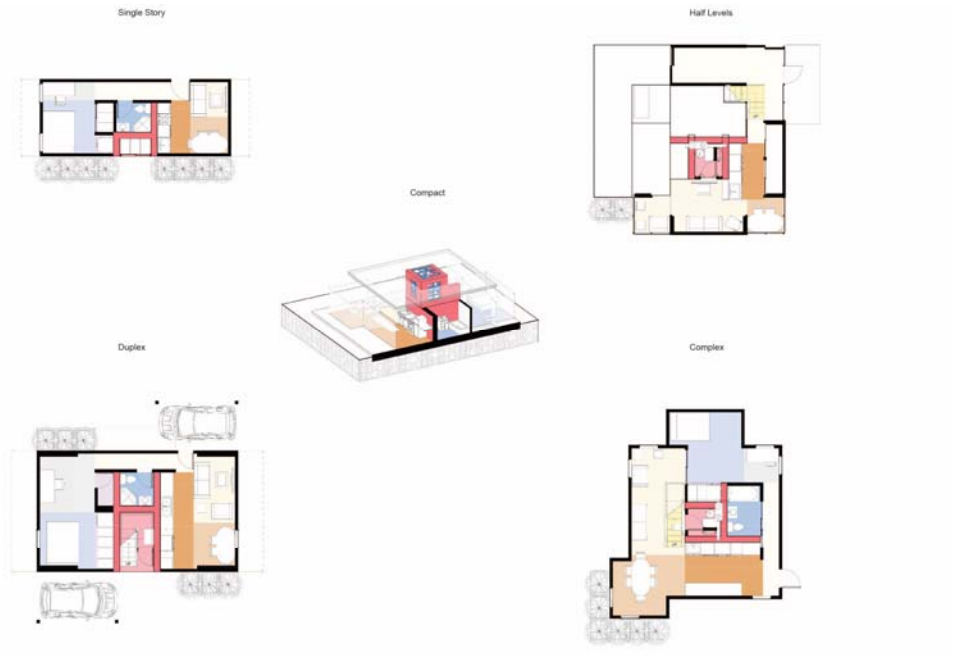


Figure 5.6 Default options for the compact scheme with DNA baseline option central to all. (Chris Courtney)

The last set of default options is for the cluster scheme. This scheme, which has prefabricated modules that can plug into the core and its systems, is the best type for growing the home vertically if site space is limited for example. Figure 5.7 shows this concept, where the cluster is perhaps the most flexible design of the three types.

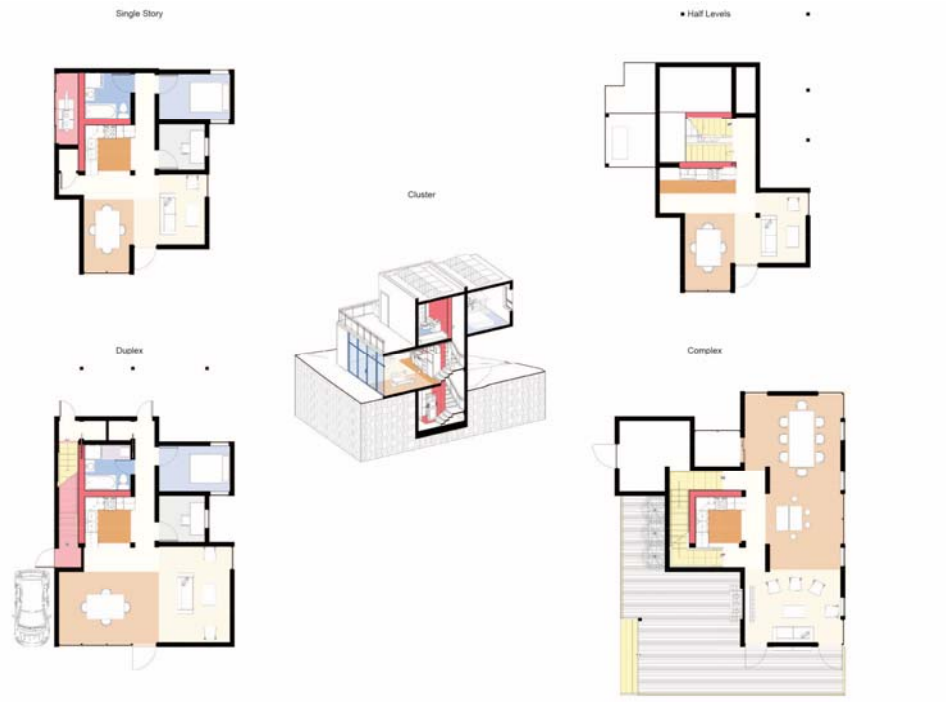


Figure 5.7 Default options for the cluster scheme with DNA baseline option central to all. (Chris Courtney)

These default types act as a starting point for both people that will or will not use the smartphone application. They are the baseline or (0,0) coordinate for every variable, but still have the concept of the core central to every scheme. These variables will change depending on the site, where one could imagine a set of baseline materials for each climate zone. Three climate zones are picked in the next section, where the idea of customizability is explored to its logical conclusion.

### Option Development

Before the hypothetical final choice for the Bylas ReAct home is chosen, one default option from each type, courtyard, compact, and cluster is explored in great detail to prove that the thesis can produce a fully loaded home as the output.

Since each home must have materials picked to prove it has been fully customized, it is useful to pick those materials based on a site. Figure 5.8 organizes each type into a location, based on the tribes that have shown interest in the ReAct home already. The corner scheme is no longer relevant as its ideas were combined with the compact scheme.

Concepts Mapped to Suitable Tribal Locations	
<b>Courtyard</b>	<b>Nanticoke:</b> (Maryland, Delaware)
<b>Compact</b>	<b>Apache:</b> (New Mexico, Colorado, Arizona)
<b>Cluster</b>	<b>Sioux:</b> (Wisconsin, Michigan, Minnesota)
<b>Corner</b>	<b>*N/A:</b> ( <i>Assimilated into Compact archetype</i> )

Figure 5.8 Chart of the three types and their corresponding site location and tribe.

While only the Apache's history was explored in detail in this thesis, the other two locations are more generalized so as to provide a backdrop for deciding what materials and mechanical systems are best suited to that particular environment, essentially the main concept of ReAct.

The first option to be fully developed is the courtyard scheme, located in Delaware where the Nanticoke tribe lives. The courtyard scheme helps extend the growing season while simultaneously creating a livable, semi-conditioned outdoor space. Many of the choices for materials and systems are very similar to the options picked for the actual solar decathlon competition entry in 2017. Figure 5.9 shows

the plan view of the shape of the chosen courtyard scheme, as well as the sections and axons.



Figure 5.9 Delaware Nanticoke courtyard scheme orthographic drawings.

The staircase in this version allows access to the 2<sup>nd</sup> story bedrooms, as well as the basement where the mechanical room is as shown in the sections. These drawing demonstrate mostly the variable, shape. The next set of drawings most clearly shows the variable, core, as the way the systems of the home work are demonstrated. Figure 5.10 shows these systems, where the focus is on the HVAC, plumbing, and electrical systems of the core, and how they are distributed throughout the house. These systems are of course fine tuned to the climate zone.

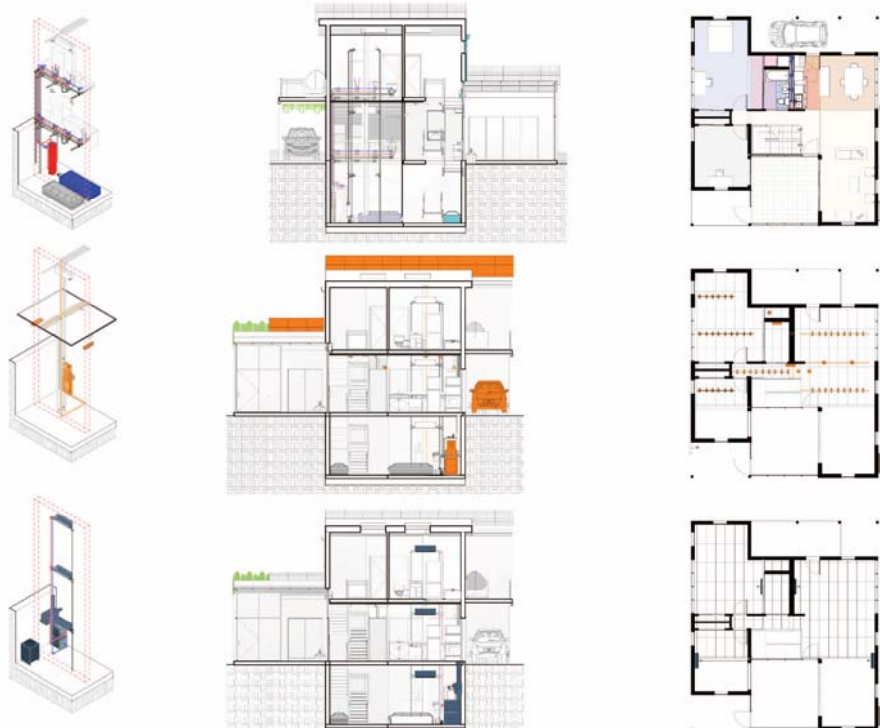


Figure 5.10 Systems core diagrams for the courtyard scheme

The systems chosen for this particular scheme includes a reverse osmosis water filtration system and automated plant drip irrigation system. The both grey water and rain water is collected and used again, while black water and food scraps are composted separately. It also includes a mini-slit HVAC system, where the outdoor unit is instead funneling heat to the solar attic, where laundry, dishes, and even food can be passively dried with waste heat and the sun. Finally, the electrical system has a LG battery which stores the DC current from the solar panels. This battery can be used, like it was in the competition, to buy and sell energy at the perfect time based on the market price, a strategy known as load shifting.

The Final set of drawings best represents the variable, materials, as the finished renders, sited in Delaware, are shown. Figure 5.11 demonstrates this.



Figure 5.11 Final renderings showing the Nanticoke courtyard home with finished materials in the Delaware site.

The materials chosen for the Delaware courtyard home are laminated bamboo siding, a sustainable and fast growing material to represent the natural, and corrugated recycled steel, to represent the artificial. The courtyard scheme combines both old passive and new high tech technologies, this this duality of man made and natural made sense, especially given the artificial qualities of core juxtaposed onto the natural qualities of the courtyard. The other materials include continuous insulation R-40 SIPS panel walls, painted birch wood panels on the interior that can be removed to access and electrical and conduits, and finally plastic composite panels for the spine wall which in this case are red. These panels can also be removed to fix any mechanical problems within the spine wall.



The second option explored is the compact scheme, located in Bylas, Arizona for the Apache tribe. The compact scheme is a mobile home, as the Apache were a mobile tribe. The wide-open desert landscape allows the home to be easily shipped and moved if needed. This home is very small, which saves on the heating and cooling costs. Figure 5.12 shows the configuration of the home in plan, section and axon.

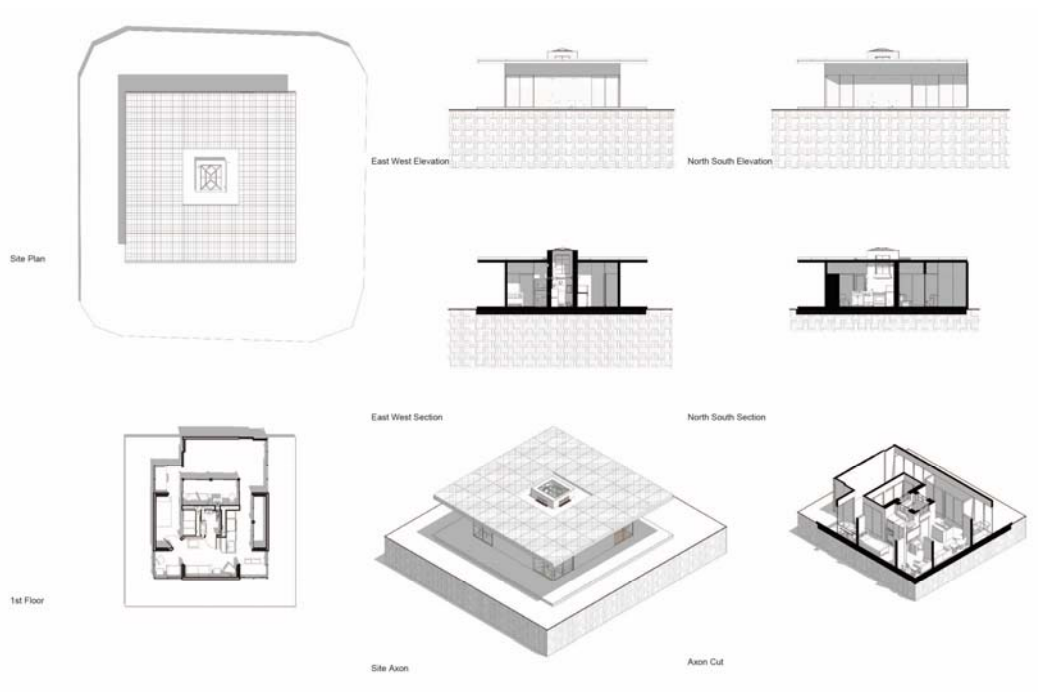


Figure 5.12 Arizona Apache courtyard scheme orthographic drawings. (Chris Courtney)

These drawing essentially demonstrate that the variable shape has been chosen. In this case, the entry way has been enlarged as a foyer or gathering room for guests, while the rest of the house is more private and consolidated. The next set of drawings focuses on the systems of the core. Figure 5.13 shows the variable core, and its corresponding systems for plumbing, electrical and HVAC.



Figure 5.13 Systems core diagrams for the compact scheme (Chris Courtney)

The systems chosen in this case include a tankless water heating system. This is due to the fact that this house is so small and has no room for a hot water tank in the mechanical room. The electrical system again uses an LG battery, but in this case is much smaller kilowatt hour size. The HVAC system uses again a mini-split system, but in this case, with less room, the heat is exhausted out the top of the core instead of utilizing that waste heat like in the courtyard. What is interesting about the compact scheme is that everything radiates from the core. It acts almost a lantern, where the light, electrical outlets, heat, cooling etc. all flow out from this core directly into the space. The exterior walls for example have no outlets. Instead, everything plugs directly into the core walls with extension cables running under the floor. The final set of drawings demonstrates the final appearance and materials of the compact scheme, as shown in Figure 5.14.



Figure 5.14 Final renderings showing the Apache compact home with finished materials in the Arizona site. (Chris Courtney)

For the compact scheme in Arizona, the materials for this mobile home are very lightweight. It uses alternating steel stud continuous insulation, with brown galvanized steel siding. The interior uses painted steel panels, with again plastic red panels for the core. Aluminum and glass is used for the windows, as wells as aluminum the spandrel running along the top of the walls.

The final type, cluster, is sited in Minnesota for the Sioux tribe. This first variable explored is shape in figure 5.15.

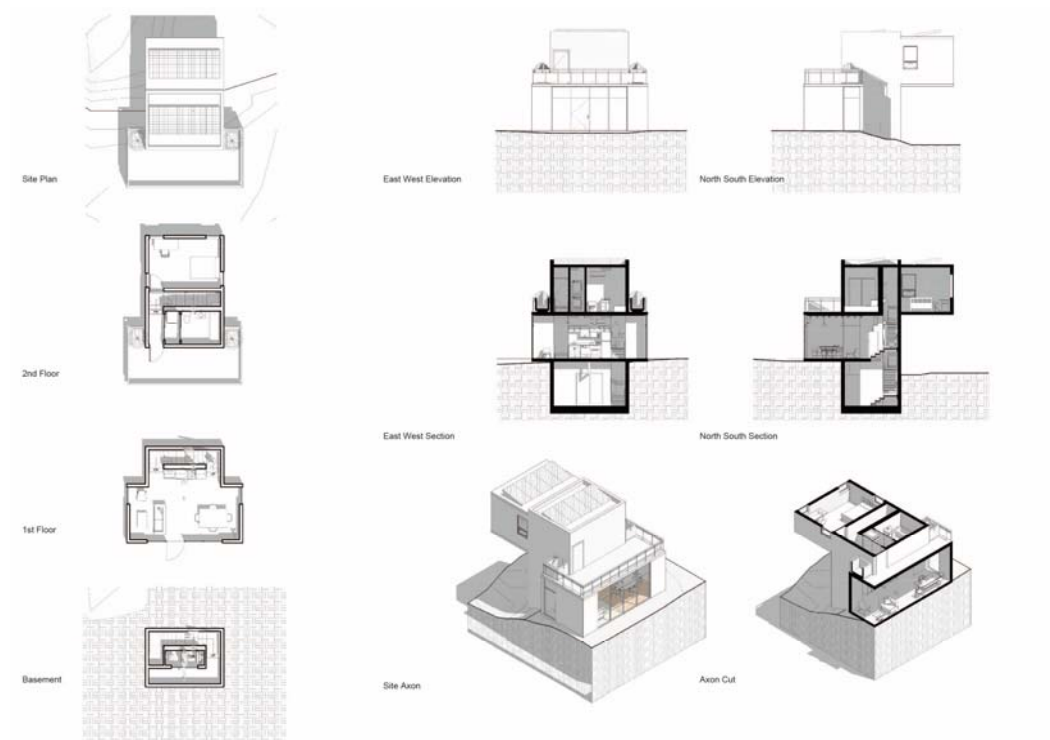


Figure 5.15 Minnesota Sioux courtyard scheme orthographic drawings. (Chris Courtney)

This shape of the cluster home is best suited for growing the home upward. More modules could be added later and plugged into the core, which digs deep into the ground to allow the prefabricated modules to cantilever out without columns.

The next set of drawings explores the core variable and its systems for the cluster scheme, as shown in Figure 5.16.



Figure 5.16 Systems core diagrams for the cluster scheme (Chris Courtney)

The systems chosen for this include a grey water filtration system and cooling system for the solar panels. The electrical system uses the same LG battery as the others. The lines for wires works a little differently, in that the C-channel structural beams act as conduit lines for the systems in the modules like outlets. The modules literally plug into the core of the house, and then gain access to power. The HVAC system is a basic central heating and cooling system, where the air is fed along the C-channel beam's conduit lines. The final set of drawings the variable material, as well as the look of the home in the site. Figure 5.17 demonstrates this.



Figure 5.17 Final renderings showing the Sioux cluster home with finished materials in the Arizona site. (Chris Courtney)

The materials in this case are local wood siding, sandstone aggregate concrete for the outer core shell upon which the modules cantilever form, and local wood panels. Again, plastic is used for the spine wall panels only to keep the drawings consistent. The renderings also show how easy it is to do maintenance on this spine wall, and the staircase is directly behind it, allow access to any height to fix a problem in the systems.

## **Chapter 6: Conclusion**

The conclusion of this thesis ends with the hypothetical client's final choice, and the process that got them there.

### **Final Output**

Figure 6.1 shows the site location, the choice of core features, and the final renderings of the home in Arizona. The diagram for the core is significant in that it relates back to figure 1.5 which shows one of the earliest diagrams ever created for the core concept for the solar decathlon. The core from that older figure is a very generic template in a sense for more specific features to get mapped onto. After inputting the unique history of the apache, site conditions, and client's preferences, and core is outputted as the final result. In this case the core has a trombe wall, vertical garden, solar loft, and lifts for the passive drying of food, dishes, and laundry.



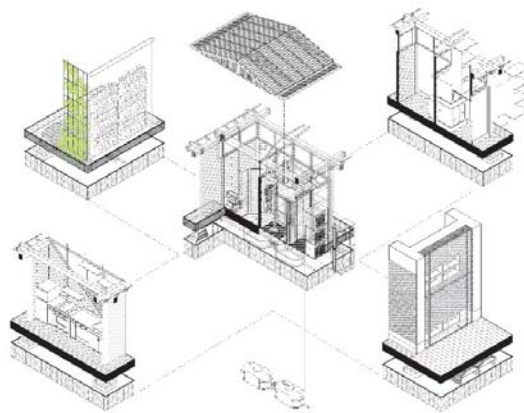
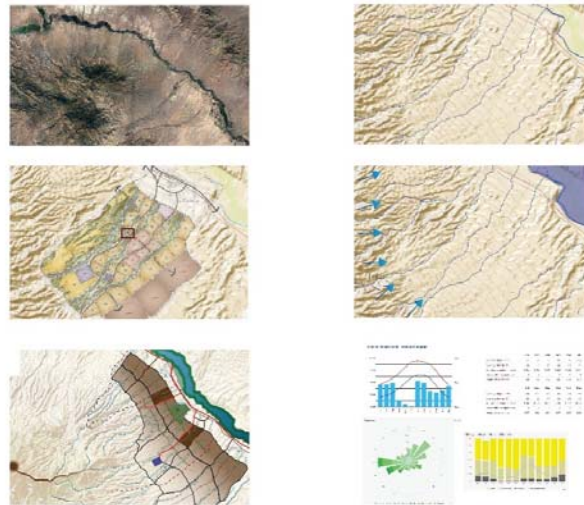


Figure 6.1 Final Choice: the compact scheme in Bylas, Arizona for the Apache.



This home should prove that the concept of a phone app, the can guide the user to sort the many variables, can successfully produce a fully loaded house, with systems and materials adapted to the climate zone. This final output, the compact home in Arizona, focus on the “half-level” default type, that has been edit to match the harsh desert climate, as well as the lifestyle and culture of the apache and their intergenerational families. It is a mobile home, but durable, like the 7<sup>th</sup> generation principles that guide the apache. The scheme is located on sloped terrain, so the levels increase by 5 ft each time, with a spiraling nature of roof decks to finish out the design. These roof tops give views of both the sacred mountain, Mt. Turnbull, and the Gila river. In conclusion, the idea that a client could use phone app to guide the design process for a more varied mass-produced community, is one that is crucially important to saving costs and the environment in the future.

Images and Figures:

Figure 1.1

NREL. "About Solar Decathlon." Solardecathlon.gov. Accessed December 3, 2016. <http://www.solardecathlon.gov/about.html>.

Figure 1.2

NREL. "About Solar Decathlon." Solardecathlon.gov. Accessed December 3, 2016. <http://www.solardecathlon.gov/about.html>.

Figure 1.3

NREL. "Solar Decathlon Contests." Solardecathlon.gov. Accessed December 4, 2016. <http://www.solardecathlon.gov/2017/competition-contests.html>.

Figure 1.4

Christopher Courtney

Figure 1.5

Christopher Courtney and Steven Pasquerillo

Figure 1.6

Tui and Hao Ming

Figure 1.7

Maryssa Timberlake and Erin Barkman

Figure 1.8

Pedro Sanchez and Boyu Li

Figure 1.9 through 1.13

Christopher Courtney

Figure 1.14

Christopher Courtney and Pedro Sanchez

Figure 2.1

Clipart Kid. "Family Symbol Clipart." Clipartkid.com. 2016. Accessed November 13, 2016. <http://www.clipartkid.com/family-symbol-cliparts/>.

Figure 2.2 through 2.7

Christopher Courtney

Figure 2.8 through 2.11

Christopher Courtney and playbuzz.com quiz creator

Figure 2.12

Christopher Courtney

Figure 2.13

WLB. "Exhibit A: Final Conceptual Land Use Plan for the New Bylas Community" JCSO Phoenix.

Figure 3.1

Compiled by Christopher Courtney and Marietta College's base map

Figure 3.2

Compiled by Christopher Courtney

Figure 3.3

TBH Web Team. "Wickiups: Sturdy but Temporary Structures."

Wickiups. Accessed November 15, 2016.

<https://www.texasbeyondhistory.net/kids/houses/wickiups.html>.

Figure 3.4

Sanchez, Bianca. "'Taos Pueblo' is a famous land mark New Mexico. It was built around 1350 by The Pueblo Indians." Pinterest. 2014. Accessed December 4, 2016. <https://www.pinterest.com/pin/326159197986039398/>.

Figure 3.5

Beautiful Places to Visit. "Anasazi." Pinterest. Accessed December 8, 2016. <https://www.pinterest.com/ekraber/anasazi/>.

Figure 3.6

Fabrizi, Mariabruna, and Ricardo Isidro Castiglia Says. "An Ancient Example of Cluster Planning: Pit Houses and Kivas in..." SOCKS. 2015. Accessed December 6, 2016. <http://socks-studio.com/2013/12/02/an-ancient-example-of-cluster-planning-pit-houses-and-kivas-in-chaco-canyon-new-mexico/>.

Figure 3.7

Choco, MnM's. "Roman atrium house plan - Google Search." Pinterest.  
2015. Accessed December 7, 2016.  
<https://www.pinterest.com/pin/510103095273819373/>.

Figure 3.8

Choco, MnM's. "Roman atrium house plan - Google Search." Pinterest.  
2015. Accessed December 7, 2016.  
<https://www.pinterest.com/pin/510103095273819373/>.

Figure 3.9 and Figure 3.10

Galyean, Crystal. "Levittown - US History Scene." US History Scene.  
2016. Accessed December 4, 2016.  
<http://ushistoryscene.com/article/levittown/>.

Figure 3.11

Sears Archive. "Sears Homes 1908-1914." Sears Homes 1908-1914.  
Accessed December 4, 2016. <http://www.searsarchives.com/homes/1908-1914.htm>.

Figure 3.12 through Figure 3.13

Prairie Crossing. "A conservation community in Grayslake, Illinois."  
Welcome to Prairie Crossing. Accessed December 1, 2016.  
<http://prairiecrossing.com/>.

Figure 3.14 through Figure 3.17

Mueller. "Mueller. A mixed-use urban village in Austin, Texas." Mueller.  
A mixed-use urban village in Austin, Texas. Accessed December 6, 2016.  
<http://www.muelleraustinonline.com/>.

Figure 3.18

Living Future Institute. "ZHome." Living-future.org. Accessed December  
10, 2016. <https://living-future.org/reveal/zhome/>.

Figure 3.19 through 3.21

Binder, Mike. "Designing a Better Future." Reality-alt.com. June 8, 2015.  
Accessed December 1, 2016. [http://reality-](http://reality-alt.com/blog/archives/442)  
[alt.com/blog/archives/442](http://reality-alt.com/blog/archives/442).Figure 3.22 through 3.24

Figure 3.22 through 3.24

Hesperia. "Hesperia's Tapestry Master-Planned Community will be a  
Jewel of the High Desert." The High Desert Report. April 17, 2015.  
Accessed December 2, 2016.  
[http://www.thehighdesertbradcoreport.com/articles/2015/04/hesperias-](http://www.thehighdesertbradcoreport.com/articles/2015/04/hesperias-tapestry-master-planned-community-will-be-a-jewel-of-the-high-desert/)  
[tapestry-master-planned-community-will-be-a-jewel-of-the-high-desert/](http://www.thehighdesertbradcoreport.com/articles/2015/04/hesperias-tapestry-master-planned-community-will-be-a-jewel-of-the-high-desert/).

Figure 4.1

Burns, David. "Impact on Indians: Reservations and Conflicts."  
Fasttracking.com. 2009. Accessed November 04, 2016.  
[http://www.fasttrackteaching.com/ffap/Unit\\_2\\_Westward/U2\\_Impact\\_on\\_](http://www.fasttrackteaching.com/ffap/Unit_2_Westward/U2_Impact_on_Indians.html)  
[Indians.html](http://www.fasttrackteaching.com/ffap/Unit_2_Westward/U2_Impact_on_Indians.html).

Figure 4.2

Whalen, Douglas. "Athabaskan Family Tree." E-MELD School of Best Practices in Digital Language Documentation. 2006. Accessed November 04, 2016. <http://emeld.org/school/case/navajo/tree.html>.

Figure 4.3

"Apache, Western (Native Americans of the Southwest)." What-when-how.com. Accessed November 04, 2016. <http://what-when-how.com/native-americans/apache-western-native-americans-of-the-southwest/>.

Figure 4.4

Decolonialatlas, /. "Extermination of the American Bison." The Decolonial Atlas. March 07, 2015. Accessed December 9, 2016. <https://decolonialatlas.wordpress.com/2015/03/07/extirmination-of-the-american-bison/>.

Figure 4.5

US Climate Data. "Climate Arizona - Phoenix." UsClimatedata.com. Accessed November 05, 2016. <http://www.usclimatedata.com/climate/arizona/united-states/3172>.

Figure 4.6

WLB. "Exhibit A: Final Conceptual Land Use Plan for the New Bylas Community" JCSN Phoenix.

Figure 4.7

Goggle Earth

Figure 4.8

Google Earth

Figure 4.9

"Mount Trumbull." Summitpost.org. Accessed November 04, 2016.

<http://www.summitpost.org/mount-trumbull/154115>.

Figure 5.1 through 6.1

Christopher Courtney



### Bibliography:

- NREL. "About Solar Decathlon." Solardecathlon.gov. Accessed December 3, 2016. <http://www.solardecathlon.gov/about.html>.
- NREL. "Solar Decathlon Contests." Solardecathlon.gov. Accessed December 4, 2016. <http://www.solardecathlon.gov/2017/competition-contests.html>.
- Courtney, Christopher. "Diagram of the four major typologies." Chart. In Work from Fall 2016.
- Courtney, Christopher, and Steven Pasquerello. "Compact: Solar Decathlon 2017." Chart. In Fall 2016 Final Project Submission, 1.
- Courtney, Christopher, and Steven Pasquerello. "Compact: Solar Decathlon 2017." Chart. In Fall 2016 Final Project Submission, 1.
- Tui, and Hao Ming. "Corners: Captivating Environment." Chart. In Fall 2016 Final Project Submission, 2.
- Timberlake, Maryssa and Erin Barkman. "Seasonal Response: Adaptive Courtyard." Chart. In Fall 2016 Final Project Submission, 2.
- Sanchez, Pedro and Boyu Li. "Cluster: Versatility and Flexibility." Chart. In Fall 2016 Final Project Submission, 1.
- Courtney, Christopher. "Customize your home's utilities within the "core"." Playbuzz.com. November 09, 2016. Accessed November 20, 2016. <https://www.playbuzz.com/sabrechr1810/customize-your-homes-utilities-within-the-core>.

WLB. "Exhibit A: Final Conceptual Land Use Plan for the New Bylas Community" JCSO Phoenix.

Marietta College. "Marietta College Biomes of the World." W3.marietta.edu.  
Accessed November 16, 2016.  
<http://w3.marietta.edu/~biol/biomes/biomes.htm>.

TBH Web Team. "Wickiups: Sturdy but Temporary Structures." Wickiups.  
Accessed November 15, 2016.  
<https://www.texasbeyonhistory.net/kids/houses/wickiups.html>.

Sanchez, Bianca. "'Taos Pueblo' is a famous land mark New Mexico. It was built around 1350 by The Pueblo Indians." Pinterest. 2014. Accessed December 4, 2016. <https://www.pinterest.com/pin/326159197986039398/>.

Beautiful Places to Visit. "Anasazi." Pinterest. Accessed December 8, 2016.  
<https://www.pinterest.com/ekraber/anasazi/>.

Fabrizi, Mariabruna, and Ricardo Isidro Castiglia Says. "An Ancient Example of Cluster Planning: Pit Houses and Kivas in..." SOCKS. 2015. Accessed December 6, 2016. <http://socks-studio.com/2013/12/02/an-ancient-example-of-cluster-planning-pit-houses-and-kivas-in-chaco-canyon-new-mexico/>.

Choco, MnM's. "Roman atrium house plan - Google Search." Pinterest. 2015.  
Accessed December 7, 2016.  
<https://www.pinterest.com/pin/510103095273819373/>.

- Galyean, Crystal. "Levittown - US History Scene." US History Scene. 2016.  
Accessed December 4, 2016. <http://ushistoryscene.com/article/levittown/>.
- Sears Archive. "Sears Homes 1908-1914." Sears Homes 1908-1914. Accessed  
December 4, 2016. <http://www.searsarchives.com/homes/1908-1914.htm>.
- Prairie Crossing. "A conservation community in Grayslake, Illinois." Welcome to  
Prairie Crossing. Accessed December 1, 2016. <http://prairiecrossing.com/>.
- Mueller. "Mueller. A mixed-use urban village in Austin, Texas." Mueller. A  
mixed-use urban village in Austin, Texas. Accessed December 6, 2016.  
<http://www.muelleraustinonline.com/>.
- Living Future Institute. "ZHome." Living-future.org. Accessed December 10,  
2016. <https://living-future.org/reveal/zhome/>.
- Binder, Mike. "Designing a Better Future." Reality-alt.com. June 8, 2015.  
Accessed December 1, 2016. <http://reality-alt.com/blog/archives/442>.
- Hesperia. "Hesperia's Tapestry Master-Planned Community will be a Jewel of the  
High Desert." The High Desert Report. April 17, 2015. Accessed  
December 2, 2016.  
<http://www.thehighdesertbradcoreport.com/articles/2015/04/hesperias-tapestry-master-planned-community-will-be-a-jewel-of-the-high-desert/>.
- Burns, David. "Impact on Indians: Reservations and Conflicts." Fasttracking.com.  
2009. Accessed November 04, 2016.

[http://www.fasttrackteaching.com/ffap/Unit\\_2\\_Westward/U2\\_Impact\\_on\\_Indians.html](http://www.fasttrackteaching.com/ffap/Unit_2_Westward/U2_Impact_on_Indians.html).

Stromberg, Joseph. "Ancient Migration Patterns to North American Are Hidden in Languages Spoken Today." *Smithsonian Magazine*. March 14, 2014. Accessed November 02, 2016. <http://www.smithsonianmag.com/science-nature/ancient-migration-patterns-north-america-are-hidden-languages-spoken-today-180950053/>.

Huscher, Betty H., and Harold A. Huscher. "Athapaskan Migration via the Intermontane Region." *American Antiquity* 8, no. 1 (1942): 80-88.

Seymour, D. J. (2009). Nineteenth-century apache wickiups: Historically documented models for archaeological signatures of the dwellings of mobile people. *Antiquity*, 83(319), 157-164. Retrieved from <http://search.proquest.com/docview/217557831?accountid=14696>

History.com Staff. "Geronimo." *History.com*. 2009. Accessed December 2, 2016. <http://www.history.com/topics/native-american-history/geronimo>.

US Climate Data. "Climate Arizona - Phoenix." *UsClimatedata.com*. Accessed November 05, 2016. <http://www.usclimatedata.com/climate/arizona/united-states/3172>.

City-data. "Bylas, Arizona." *City-data.com*. 2010. Accessed November 04, 2016. <http://www.city-data.com/city/Bylas-Arizona.html>.

"Mount Trumbull." Summitpost.org. Accessed November 04, 2016.

<http://www.summitpost.org/mount-trumbull/154115>.

Schachter, Josh. "Southeastern Arizona Arts in Academics Residencies."

Joshphotos.com. October 2009. Accessed November 3, 2016.